STUDIES ON THE VARIATION, DISTRIBUTION, AND EVOLUTION OF THE GENUS PARTULA

THE SPECIES OF THE MARIANA ISLANDS, GUAM AND SAIPAN

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INTRODUCTION.

NATURE AND BEARING OF PRESENT INVESTIGATION.

The present volume is the second to be completed in a series of detailed analytical studies on the genus *Partula*. The first volume[1] dealt with the species of Tahiti, the largest and best-known member of the Society Islands, situated in southeastern Polynesia. The studies on the representatives of the genus that inhabit Tahiti may well be designated fundamental, both because the Society Islands constitute the present headquarters of the whole genus, and also because the investigations in question served to develop the methods by which the subjects of variation, distribution, and evolution in the case of other island associations may be analyzed, to the extent that time and opportunity may determine.

While it had been expected that the second volume to be prepared would deal with the species of Moorea—an island adjacent to Tahiti in the Society Group—that expectation has not been realized, first on account of the Great War and its prior claim on the services of the writer, and second because the field-work in that and other islands of the headquarters group remained to be completed. Meanwhile, in 1920, an occasion presented itself for a study of Guam and its neighbors in the Mariana Group, located in the western Pacific Ocean. The opportunity was seized because, with the foundation laid in the studies of the genus at its headquarters, it was thought that an investigation of an outlying territory would serve to bring into clearer relief such basic principles of ecology, distribution, and relationship as were common to widely-separated areas which might be somewhat unlike in secondary details. The event has justified the decision, in ways that will be described in subsequent sections of the present volume.

A long-deferred leave from academic duties at Barnard College afforded the opportunity to which reference has been made and the months of July and August of 1920 were allotted to the investigations in the Mariana Islands. Being at the time Curator of Invertebrate Zoology at the American Museum of Natural History, plans were developed in the interests of that institution for extensive collecting in areas of Micronesia, southeastern Asia, Malaysia, and Australia; and in the consummation of these plans additional information regarding tropical ecology was gained. The present research was made possible by the generous support of the Bernice Pauahi Bishop Museum of Honolulu, for it seemed to Director Herbert E. Gregory and to the Trustees that the ecological investigations proposed by the author would be useful in connection with their comprehensive explorations of the whole Pacific area as well as in relation to the intensive studies upon terrestrial gastropods long carried on by C. Montague Cooke; the author's grateful acknowledgments to the administrative and scientific staff of the Bishop Museum are herewith and all too briefly recorded.

[1] H. E. Crampton, *Studies on the variation, distribution, and evolution of the genus Partula. The species inhabiting Tahiti.* Carnegie Inst. Wash. Pub. No. 228, 1917.

The following brief statement will indicate the nature and general bearing of the work:

1. The present volume is concerned with the intrinsic nature and with the environmental relations of the species of *Partula* which exist in the Mariana Islands. Attention is focused directly upon the characters of the snails themselves, the diversities of such qualities, and the distribution of the several species and their distinguishable variations. In addition, all of the ecological conditions are considered with regard to their possible effects upon the presence, nature, and distribution of the snails.

2. Field-work was carried out in Guam with an approach to complete exploration, and also to a partial extent in the northward island of Saipan.

3. The *Partula* population of Guam consists largely of representatives of two species, *P. gibba* and *P. radiolata*, whose varying conditions are described as exhibited in the 39 areas where collections were obtained. The greater part of the present volume consists of the detailed description of these two species.

4. The inter-island comparison of Guam and Saipan, 120 miles apart, is made on the basis of the one species which is common to the two areas, namely, *P. gibba*.

5. A rare and unfigured species, *P. fragilis* of Férussac, has been found in Guam in sufficient numbers for a complete study. This is the species called *P. quadrasi* in Pilsbry's *Manual*, with the suggestion that it is Férussac's lost kind. It is unique in the entire genus, as far as the author is aware, inasmuch as reproductive ability is manifested before the expanded lip of the shell develops.

6. A new species has been discovered in Guam on the remote peak of Mount Salifan, and on account of the locality the new form is named *P. salifana*. The animals of this species are large and well-developed; yet, despite the fact that Guam has been a well-known collecting-ground for a full century, they have never before been found owing to the seclusion of their habitat.

7. The question as to the originative value of the environment, as contrasted with congenital causes of differentiation, may be answered even more positively than in the case of the Tahitian study. All of the evidence proves that specific and racial diversification of the material under investigation is due to the operation of internal factors and not to external influences.


Ritidian Pt.
Tarague
Pati Pt.
Santa Rosa 870'
Ukudu
Dededo
Tumon Bay
Barrigarda 674'
Agaña Bay
Presido
AGAÑA
Cabras I.
Orote Pt.
Apra Harbor
Orote Peninsula
Macajna 700'
Chachao 1046'
Alutom 1082'
Tenjo 1022'
Pago R.
Pago Bay
Agat
Ylig R.
Salifan
Alamagosa
Facpi Pt.
Lamlam 1280'
Jumullong Manglo 1274'
Umatac Bay
Bolanos 1240'
Inarajan R.
Mt. Schroeder 1054'
Sasalaguan 1120'
Inarajan
Merizo
Cocos I.
TRUE NORTH
MAGNETIC NORTH
1 ½ 0 5 MILES

Map of Guam.

CHAPTER I.

THE MARIANA ISLANDS AND THEIR ECOLOGICAL CHARACTERISTICS.

GENERAL CONSIDERATIONS.

While the present volume is complete in itself as an investigation of the nature and ecology of the species of *Partula* which occur in the Mariana Islands, obviously there are certain features of the oceanic realm and certain characteristics of the animals themselves that are fundamental for the consideration of the specific area in question and of its own peculiar types. The earlier volume on the species of Tahiti comprises an account of the distribution of these animals in islands of the Pacific Ocean; it is necessary to re-state here only a few of the basic facts which are particularly important.

The land gastropods of the genus *Partula* are restricted to Oceania in its widest sense, although they do not occur everywhere throughout this great area. They are absent from the Hawaiian Islands, but the classic Achatinellidæ of that group are their near relatives. With few exceptions, the snails are found only on the larger "high" islands of volcanic structure, or on composite islands consisting of limestone as well as of volcanic materials. Although the animals crawl about upon the vegetation of suitable areas, or more rarely upon the ground, apparently they subsist upon the mycelia of fungi which grow on decaying plant materials. The areas of habitation in the islands of their occurrence are conditioned by a complex of environmental circumstances, such as moisture, shade, higher temperature, and altitude.

The favorable nature of Oceania for studies upon variation and distribution can not be over-emphasized. The following quotation from the volume on the Tahitian species (*loc. cit.*, pp. 13, 14) presents the case concisely:

> The situation being what it is, it would be impossible to find a more ideal combination of circumstances for the investigation of the members constituting a definite biological group, and of their geographical distribution. The total area of occurrence is large, exceeding that of the United States; within this, the habitable bodies of land are separate islands, more or less distant from one another, associated in lesser or greater numbers in groups that lie relatively near or far apart. Hence the degrees of geographical relationship are marked with extraordinary distinctness, without any question of intermediate connections that intervene between comparable ecological regions of a single continent. Furthermore, it has long been known that within the confines of a solitary island, the areas suitable for the existence of Partulæ are more or less isolated valleys, whose differing forms may be analyzed in correlation with their geographical and topographical proximity. In brief, then, the valleys and their diverse species constitute elements of a primary order, to be compared with one another; such elements taken together form an island-complex, which, as an element of a second order, may be contrasted with a similar complex of another island in the same association; uniting the several islands into a combination of a tertiary grade—the island group and its species—this may be investigated as a whole in relation to other combinations of the same status in different parts of the whole area. The circumstances are such, then, as to give an unusual interest and significance to the investigation of the genus *Partula* and its distribution, on the basis of a systematic and detailed analysis not ordinarily possible when dealing with similar problems of zoogeography.

In accordance with the general principle that the degree of resemblance between two species, or between distinguishable varieties of a single species, is correlated with the degree of their geographical proximity or remoteness, the Par-

FIG. 1.—Southern islands of the Mariana or Ladrone Group. (From Natural History, vol. XXI, No. 2, 1921.

tulæ of one group of islands are different from those which exist in another archipelago, while the individual islands of one and the same geographical association have their own unique species; furthermore, the forested areas of the valleys in a single island possess different varieties of a widespread species in correlation with their separation by barriers to the free inter-communication of their organisms. Like all general statements, however, qualification is necessary in exceptional instances, as for example in the case of *Partula hyalina*, which as one and the same species inhabits Tahiti as well as certain members of the Cook and Austral Groups.

The Mariana Islands are more than 4,000 miles from the present headquarters of the genus in the Society Islands. They lie in the extreme northwestern part of the whole range (cf. plate 1, opposite p. 13, volume on Tahiti); together with the long complex chain of the Caroline Islands, the Bonins, and a few scattered elements, they constitute the subregion of Oceania called Micronesia. In Parts 79 and 80 of Pilsbry's *Manual of Conchology*, 10 species are attributed to Micronesia as a whole, as follows: Pelew Islands, 3; Caroline Islands, 4; Mariana Islands, 3. The present investigation increases the last number to 4; and these are particularly interesting on account of their remoteness from the generic headquarters in Polynesia, and also on account of their contrasts in certain ecological respects with the species of Tahiti and its neighbors. The second subregion of Melanesia lies to the south of Micronesia, with 37 species on record from the Fiji, New Hebrides, Santa Cruz, and other contiguous groups of islands. The third and largest subregion, Polynesia proper, occupies the southeastern part of the whole area of Oceania, and from this division more than 60 species have been secured by naturalists. The prominence of the Society Islands in this subordinate area is attested by the fact that the 6 largest islands of the group are the homes of as many as 44 of the Polynesian species. In brief, then, the Mariana Islands bear few species of the genus, and they lie quite at the extreme northwestern limit of the whole oceanic area in which *Partula* occurs.

GEOGRAPHY, GEOLOGY, AND PHYSIOGRAPHY.

The long chain of islands which constitute the Mariana or Ladrone Group comprises 15 elements of smaller and larger size, together with a few scattered reefs and banks. They are extended along the line of an almost perfect upright bow with its convexity toward the east. Guam is the southernmost and largest member of the group (text-fig. 1), and its own southern point is located approximately at latitude 13° 14′ north, longitude 144° 40′ east. The northern end of the arc is marked by the small volcanic cone of Uracas, at latitude 20° 30′ north, longitude 144° 55′ east. The point of greatest convexity is occupied by the island of Medinilla, which is exactly at the junction of the sixteenth parallel north with the meridian of 146° east. These figures indicate the slight degree of curvature of the entire submarine range, 420 miles in length, whose peaks constitute the several islands of the group.

A line running almost due north-northeast from Guam (text-fig. 1) leads first to Rota, 30 miles distant, and then to the small island of Agiguan, 45 miles beyond Rota. A short interval of only 5 miles separates Agiguan from Tinian, 10 miles in length. Saipan is next in order, only a little over 2 miles from Tinian; it is next in size to Guam, being about 10 miles in length and slightly less than 5 miles in greatest width.

Guam, Tinian, and Saipan are the only islands which are reported as the habitations of Partulæ, and therefore we have no real concern with the smaller members of the group to the northward. As stated above, field-work was carried out in Guam and Saipan; it was impossible to visit Rota and Tinian, despite their seeming proximity, owing to unsettled and dangerous typhoon weather and to the insuperable difficulties of transportation.

All of the islands of the group are volcanic in origin, in whole or in part. Some of the lesser elements to the north are almost perfect single cones, while others are multiple in nature; their recent construction is indicated by continued eruptions from their craters as well as by their simple uneroded contours. The height exceeds 2,000 feet in some instances, such as Alamagan. The age of the islands is regularly greater as one passes southward; Saipan is clearly a much older element than the northernmost islands, while Guam is a product of a still earlier period of construction and the most ancient of them all. Limestone forms a large part of the southern land-masses, which comprise wide strata of such materials now raised high above the sea. Living coral reefs fringe the coasts of some of the southern islands, mostly on their western sides, but such reefs do not occur about the northern elements.

The island of Guam has a length of about 29 statute miles on a line running from south-southwest to north-northeast—a direction that coincides very closely with that of the line passing to Rota, Tinian, and Saipan (plate 1). At its center, Guam is only 4 miles across, while in the wider areas to the north and south the breadth varies from 7 to 9 miles.

Although they are so directly continuous, the two main portions of Guam differ markedly in geological respects and consequently in ecological conditions. Viewed from a distance, the northern (or northeastern) half appears to be an almost flat plateau, raised from 200 to 500 feet above sea-level (plate 2, A and B). On closer study, this part proves to be composed of elevated reef-limestone, very much worn and sculptured, through which volcanic masses have broken their way, as attested by the metamorphosis of the contiguous calcareous rock. Barrigarda is such an extruded mass, 674 feet in height, near the geographical center of the island; Santa Rosa, of the same nature, reaches a height of 870 feet, and is situated about 6 miles to the east-northeast of Barrigarda. Elsewhere in the northern half of Guam only a few hillocks rise decidedly above the general level of the plateau. The elevated reefs are not simple, however, for investigation discovers at least five component strata, tilted somewhat from north to south and from east to west. In summary, this part of Guam consists mainly of a series of limestone terraces, not exactly level, which have been raised by a succession of uplifts alternating with periods of quiescence.

The southern half of Guam is very different, as it is primarily a volcanic massif with restricted calcareous strata around its base. A somewhat irregular range of mountains runs more or less parallel to the west coast (plate 1 and plate 3, A, B, and C), with the highest points from 1 to 2.5 miles back from the shore, and from 700 to more than 1,300 feet of altitude. Necessarily the westward slopes of these

A. Open mid-west coast of Guam, with the northern limestone plateau in the distance.

B. Western border of the northern plateau of Guam, with abrupt cliffs devoid of thick vegetation.

mountains descend rapidly; the eastern faces are equally abrupt at first and then become more gradual as they merge into the lower slopes extending to the eastern shores.

Although the range of higher land is virtually continuous, three constituent parts can be distinguished. The northern portion lies west of the narrow median neck of the whole island, and its lower levels are composed largely of limestone; the high points are Mount Chachao, 1,046 feet, Alutom, 1,080 feet, and Tenjo, 1,013 feet. South of this group of peaks the terrain is considerably lower, and at present it is so barren as to constitute a barrier to the crossing of snails from the northern group of uplands, inhabited in part by the animals, to the middle section of the range, or *vice versa*. Beginning with Mount Salifan, 858 feet high, the median section of the range extends south to Alamagosa and Lamlam, 1,334 feet, Jumullong Manglo, 1,274 feet, and so on to Bolanos, 1,240 feet, which lies directly east of the village of Umatac (plate 3, B and C). Only a slight depression intervenes between Bolanos and the smaller group of mountains that constitute the third and southernmost section of the entire range; the main peaks of this last division are Mount Schroeder, 1,054 feet, and Sasalaguan, 1,110 feet high (plate 3 C).

The limestone strata of the southern half are continuous with those of the north, and they conform also in their inclinations. Hence as the observer passes from north to south along the western coast, the uplifted reef rock gradually decreases in height, until at Merizo, at the southwestern extreme, it becomes virtually continuous with the living reef beyond the shore. As in the north, so in this part of Guam, the limestone cliffs are high on the eastern side, but passing inland, the rock of the lofty coastal bluffs disappears beneath the overlying materials washed down from the volcanic masses of the principal range of mountains.

Rainfall is quite heavy, but there are no constant streams in the northern part of Guam, owing to the receptive nature of the rock and its internal drainage. In the southern volcanic portion, many streams exist which flow with brief courses on the western side, while those upon the eastern slopes are necessarily longer. The latter run between the relatively abrupt bounds which have been cut by earlier erosive action through the tuffs and limestone rock of their territory. The physiographic features thus outlined are most important, because the areas of vegetation that are suitable for Partulæ are directly conditioned by them.

Inasmuch as collections of *Partula gibba* were taken from several localities on the western side of Saipan, the general geological nature of that island requires brief consideration. Saipan consists largely of coral limestone surrounding a volcanic base. In topographic respects it is a very simple unitary mass, rising to a single high peak, Mount Tapochau, about 1,530 feet in height (plate 8 A); the slopes descend gradually and evenly, and are not grooved by large and deep valleys and gullies. Along the western side, from Tanapag to Agingan at the southwestern point, there is a flat coastal plain which attains a maximum radial width of more than a mile; but elsewhere the borders of the island are relatively abrupt as they reach the sea. Hence in general contour, Saipan is much more like the southern than the northern part of Guam, although its constituent rock is so largely calcareous. Only the high prominences are volcanic, as the summit of Mount Tapochau itself, of Marpi to the north, and of similar uplands.

Tinian is low and flat. It is composed almost entirely of reef limestone, low on the western side and sloping upwards to about 150 feet on the east. A few hills of volcanic nature rise to various heights above the general limestone levels; the highest of these stands well to the southeast and attains an altitude of 300 feet. This island, in contrast with Saipan, closely resembles the northern half of Guam.

Rota consists of two portions joined by an isthmus, both of which display the terraces of uplifted reefs like those of northern Guam and of Tinian, but with much greater distinctness. A volcanic nucleus exists in the larger element of Rota, and it rises to the somewhat remarkable height of 800 feet.

THE SURROUNDING FLOOR OF THE OCEAN.

Although the present researches are biological in character, they are necessarily concerned with the strictly geological problem as to the prior existence of a great land-mass, or a group of land-masses, in the western and southern Pacific Oceans. According to one hypothesis, the subsidence of such territory or territories would leave only the peaks above the water's surface as the several islands now in existence. The opposed view is that volcanic upheaval has been the principal if not the sole process by which such small land areas have been formed. The pertinent facts of zoogeography are that the neighboring islands bear species of Partulæ that are closely similar or even specifically identical, as in the case of *P. gibba*, which exists in Guam, Tinian, and Saipan in the Mariana Group. On the basis of the subsidence hypothesis a widespread parental stock of the original land-mass would be separated into the isolated daughter stocks of disconnected islands, whereupon evolutionary divergence might or might not ensue. If the alternative hypothesis of uplift were true, then a newly arisen island must have gained its vegetation and its *Partula* population by immigration from other and older islands. Almost inevitably such immigrants would come from the nearer inhabited areas; as in the alternative case, their subsequent history might be one of diversification or it might not, as circumstances would direct.

In the volume on the species of Tahiti, the position was taken that subsidence has occurred in the Society Islands, and that widespread ancestral stocks have been dissected, as it were, into the separate insular associations of to-day. It does not follow, of course, that every island group in Oceania has had the same history, or that the reverse phenomenon of uplift can not be manifested in an area in which subsidence is the dominant process; it is clearly apparent that much of the rock in the southern Mariana Islands, as in many another part of Oceania, was constructed as coral reef, and that the earth-strains of subsequent periods forced it up to high levels above the sea. In the view of the author at the present time, subsidence has been the general process by which an ancient land-mass has been converted into lesser disconnected areas, which in turn have been so depressed as to leave only the peaks above the sea, as the islands now existing in the Pacific. The history is a difficult one to establish and many geological considerations may be

A. Southern portion of Guam, western aspect, from Apra Harbor.

B. View into Umatac Harbor, Guam. Mt. Bolanos on the left and part of Mt. Schroeder on the right.

C. Southwestern portion of Guam. Mt. Bolanos left, Mt. Schroeder right center, peak of Mt. Sasalaguan extreme right.

urged against its acceptance, but the biological facts are such as to demand just such a geological explanation.

Clearly the character of the submarine territory in the neighborhood of the Mariana Islands is most important in the present connection. The available data, which are unfortunately scanty, are derived mainly from the survey of the U. S. S. *Nero*, conducted in 1899 with a view to the laying of a trans-Pacific cable to Guam.[1] In general, the submarine topography is such as to emphasize the present isolation of the Mariana Islands in all directions except the north.

In the first place, the several islands of the group form the peaks of a continuous range, for the depths between consecutive elements are far less than elsewhere in the neighborhood where soundings have been taken; between Guam and Rota, for example, one station gives 470 fathoms and another shows 690 fathoms, a little away from the direct line. In the second place, the geographical position and volcanic texture of the Bonin Islands would indicate their structural continuity with the Mariana Islands; by way of confirmation, the U. S. S. *Nero* found a submarine mountain range which actually connected the two groups in question. As the Bonin Islands themselves are structurally connected with Japan, evidently there is an extensive, continuous, and almost straight zone from Japan to Guam in which volcanic tectonics are most clearly marked.

A third feature of great importance is the isolation of the Mariana Islands so far as the east, west, and south are concerned. Despite the seeming proximity of the Caroline Islands, the depth of 3,000 fathoms within 60 miles of southing indicates the present fundamental separation of the above-specified zone from the mass whose highest points constitute the extensive series of islands from the Pelews to the Marshalls. To the west of the Marianas the depth increases rapidly to about 2,000 fathoms within 30 miles of dry land; although the bottom undulates somewhat for 600 miles, with the approach to the Philippine Islands it descends to 3,000 fathoms and more, almost to the last-named group itself. Finally, to the east lies the profound abyss of the "Nero Deep,"—the greatest known depth of the oceans—with soundings of more than 5,000 fathoms, or a little less than 6 miles. At a greater distance from Guam in this direction the ocean floor bears numerous reefs and submerged mountain ranges which diminish in frequency with the nearer approach to the Hawaiian Islands.

In brief, then, the Mariana Islands of to-day prove to be well-separated from neighboring territories, saving only in the northward direction. The degree of isolation would seem to be such as to militate against the hypothesis of an origin of the present islands by the subsidence of a larger mass, while the theory of uplift seems to be directly supported by the geological nature of the islands, as well as by their location in an extensive zone of volcanic activity. But the vulcanism is that of to-day and of recent geologic time; what rock may constitute the core of the present islands and of the submarine cordillera beneath is of course unknown. However, if we may judge from the facts in the case of the Society Islands, the

[1] Report of the Secretary of the Navy, 1900, pp. 299–302, cited by W. E. Safford, *The useful plants of Guam*, Cont. U. S. Nat. Mus., vol. 9, 1905.

exposed reefs and the volcanic materials may well cover a far more ancient massif of basic nature, whose subsidence so altered the isostatic conditions as to bring about the partial compensation of volcanic outflow.

Turning to the biological considerations, it must be emphasized that the very fact of the present isolation of the Mariana Islands, especially on the southward side, strongly supports the subsidence theory, which at first sight it would appear to confute. If the islands in question had arisen *de novo*, then the Partulæ now inhabiting them could not be considered as indigenous, in the sense that the species of the Society Islands are held to be original. It would be necessary to postulate an immigration into such areas from other islands bearing Partulæ at the time. We know from the situation in the Society Islands that the snails of one island are not transported to a nearby neighbor in the same group, either by floating rafts or by human agencies. Hence, *a fortiori*, we would not expect oceanic drift to bear new settlers to the Mariana Islands from other groups, such as the Caroline Islands, when the degree of isolation is as great as it proves to be. Despite the geological difficulties, the biological findings strongly support the view that the dominant process in this part of Oceania has been one of subsidence and of insular dissection.

It may be that further study of this problem will alter the author's present conclusion; however, the original evolutionary history of the Mariana species of *Partula* is not the subject of discussion at this time, for we are here concerned with the detailed analysis of the *Partula* inhabitants within the confines of the group as it now exists. The problem of external relations may well await its due consideration when additional studies of specific island associations of this genus shall have been completed.

CURRENTS, WINDS, AND STORMS.

As in the volume on the Tahitian species of *Partula*, the position is taken that the winds and currents have not been active in any way or degree as factors of the dispersal and distribution of the forms now under discussion. It is true that one of the Guam species, *P. gibba*, occurs also in Tinian and Saipan, and possibly in Rota, and that these islands lie in a direction which is to the leeward of Guam during certain months of the year. It is therefore conceivable that masses of vegetation could be carried from Guam to the neighboring islands by winds and currents, there to be stranded upon the shores; in such cases, were snails adhering to the leaves and branches of the floating rafts, they might become the first settlers in a previously uninhabited area. But it is not believed that the conditions for such an episode are fulfilled; the winds are only indirect influences, *not on the dispersal and inter-island transport* of the snails, but upon the amount of rainfall and the degree of humidity, which factors directly condition the mobility and feeding habits of the animals in a given suitable region of vegetation on an inhabited island.

The winds vary in their directions throughout the year, in ways that are precisely indicated by the figures for an illustrative period, 1902, as given in Safford's invaluable compendium (table 1). In general, it appears that a trade-wind of considerable power and regularity blows from the northeast and east during the greater part of the year. This wind becomes less steady with the advent of June;

during July and August the breezes are much lighter in force and veer irregularly from quarter to quarter. The strong southwest monsoon blows throughout September, and then the winds change back to the opposite northeast quarter, or at least to the eastern half of the compass. The northeast winds are "dry," while the southwest winds carry an excessive amount of moisture during the mid-year period. As a detail, it may be noted that Guam is not large enough to cause the diurnal production of land breezes, nor are its mountains sufficiently high to affect the prevailing winds to a material degree.

TABLE 1.—*Directions of the winds at Guam, throughout an illustrative year, 1902 (from Safford). The figures give the numbers of days.*

Month.	North.	North-east.	East.	South-east.	South.	South-west.	West.	North-west.	Vari-able.
January	....	16.5	11.0	2.5	1.0	....	....	....	....
February	....	12.0	9.5	6.5	....	....	....	....	....
March	0.5	16.5	12.5	0.5	0.5	0.5	....	....	....
April	....	20.0	8.0	1.5	....	....	....	....	....
May	....	13.0	14.5	1.5	....	....	....	....	2.0
June	....	6.5	17.0	4.5	1.0	....	....	....	1.0
July	....	13.0	5.5	6.5	4.0	1.0	....	....	1.0
August	1.5	1.5	2.5	5.0	6.5	3.0	3.5	1.0	6.5
September	....	....	....	....	6.0	16.5	5.0	2.5	....
October	....	4.0	10.0	3.0	6.0	1.0	1.0	....	6.0
November	4.0	6.0	14.0	0.5	3.0	....	0.5	....	2.0
December	2.0	8.0	21.0	....	....	....	....	....	....
Summary	8.0	117.0	125.0	32.0	28.0	22.0	10.0	3.5	18.5

Under the influence of the trades, the surface water of the ocean sets to the westward at a rate, at times, of 2 knots. The current thus induced would bear floating objects to the open ocean areas devoid of proximate islands. When the southwest monsoon blows, from July to September, the drift is to the northeast, that is, from Guam in the direction of Rota, Tinian, and Saipan. Floating seeds and leaves might thus be carried to the shores of the latter islands in the path of the drift in question; but the Partulæ of an island like Guam for the most part frequent the shaded places back from the strand, and they are not likely to be borne to the sea on leaves, seeds, or larger fruits like the coconut. It is much more significant that the animals can not tolerate submersion or repeated washing in salt water, even though they can retain their vitality in fresh water for a limited time.

Typhoons are of infrequent occurrence, but are intense and cause great havoc. It is generally conceded that the devastating storms of this nature which sweep down upon the Philippine Islands usually develop in the Micronesian area in the neighborhood of Guam. They do not always gain their full strength before passing to the westward, but occasionally they do. The terrific winds of a typhoon are the result of an excessively low barometric center, which likewise causes an exceptional amount of precipitation, amounting in some instances to 9 inches in a single day. At such times, various fragments of trees and shrubs are blown to the sea, or are swept by the deluge of rain into the swollen streams which discharge into the ocean, thus to come under the influence of the currents of the time and season. While it is conceivable that Partulæ might be carried to sea upon the detached vegetation, it is not at all probable that the animals could remain alive during the time required for the slow journey of their rafts to another habitable area, under the influence of the winds and currents.

It is in other ways that the inorganic factors here discussed affect the lives of the present research organisms, so far as they are involved in the whole combination of circumstances which collectively determine the amount of rainfall and degree of humidity.

TEMPERATURE AND RAINFALL.

By virtue of their situation within the tropics, the Mariana Islands are very warm and humid, and hence their forested areas are virtually ideal habitations for snails of the genus *Partula*.

TABLE 2.—*Statistics of temperature for 1902 at Agaña, Guam (after Safford).*

Month.	° F.				° C.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean daily range.	Mean.	Absolute maximum.	Absolute minimum.	Mean daily range.
January	79	86	70	8	26.1	30.0	21.1	4.4
February	80	86	71	8	26.7	30.0	21.7	4.4
March	80	87	72	10	26.7	30.6	22.2	5.6
April	81	87	73	8	27.2	30.6	22.8	4.4
May	82	88	72	9	27.8	31.1	22.2	5.0
June	82	90	73	10	27.8	32.2	22.8	5.6
July	81	90	75	9	27.2	32.2	23.9	5.0
August	81	88	74	9	27.2	31.1	23.3	5.0
September	80	87	73	11	26.7	30.6	22.8	6.1
October	80	88	70	10	26.7	31.1	21.1	5.6
November	79	85	69	11	26.1	29.4	20.6	6.1
December	78	85	66	9	25.6	29.4	18.9	5.0
Annual maximum	82	90	..	17	27.8	32.2	....	9.4
Annual minimum	78	..	66	3	25.6	....	18.9	1.7
Mean	80	87	72	9	26.7	30.6	22.2	5.0

Not only is the climate warm, but it is remarkably equable as well, for the limits of diurnal and annual variation are unusually narrow. The exact figures for the capital of Agaña during the illustrative year of 1902 are given in table 2, which presents the substance in modified form of the temperature table in Safford's volume; the organization of the records, as stated by Safford, was the work of Cleveland Abbe, Jr. The figures show a high general temperature with a gradual increase from January to June, and a subsequent regular decrease to December. The general monthly mean, the absolute maxima, and the absolute minima are entirely consistent indications of a long, slow, and low thermal pulse throughout the year. The difference between the absolute extremes for the year is astonishingly small, amounting as it does to only 8.4° C.

It is to be kept in mind that the foregoing data were acquired at the single station at Agaña in Guam, and that the actual records taken in other parts of the island would assuredly differ in absolute figures. Clearly the forested areas are cooler than the capital town, whose roads and avenues bear little vegetation, if any, while furthermore it rests under the lee of hills which cut off the breezes from many quarters. Then, too, the influence of altitude in the higher areas is positive, especially in the southern half of the island; it was found in Tahiti that the average temperature diminished to the extent of 5° C. for every thousand feet of added height. The uplands of Guam are by no means as lofty as the great mountains of Tahiti, and the same general scale might not hold in the present instance; yet experience proves that the temperature of the hills is lower than that of the coasts. Making all due allowances, however, it is justifiable to conclude that the temperature deviations are not very great in degree, while the seasonal cycle would assuredly be the same in kind in all parts of Guam as well as in the neighboring islands which are inhabited by Partulæ.

TABLE 3.—*Statistics of rainfall for 1902 at Agaña, Guam (after Safford).*

Month.	Inches.		Millimeters.		Percentage of annual rainfall.	Number of days with rain.			
	Total.	Maximum in 24 hours.	Total.	Maximum in 24 hours.		More than a trace.	More than 0.1 inch.	More than 0.5 inch.	More than 1 inch.
January	3.58	1.01	90.93	25.65	3.1	18	11	2	1
February	7.30	2.24	185.42	56.90	6.3	21	9	4	3
March	3.21	0.90	81.53	22.86	2.8	16	9	2	..
April	3.87	0.71	98.04	18.03	3.3	19	11	3	..
May	4.55	0.92	115.57	23.37	3.9	22	9	3	..
June	7.14	2.92	181.36	74.17	6.1	25	12	4	1
July	16.06	6.26	407.92	159.00	13.8	28	17	7	5
August	19.72	4.72	500.89	119.89	16.9	28	23	12	4
September	27.01	5.31	686.06	134.87	23.2	27	26	15	8
October	9.63	2.81	244.60	71.37	8.3	21	12	7	3
November	11.86	2.62	301.24	66.55	10.2	25	17	6	4
December	2.53	0.77	64.26	19.56	2.2	15	9	1	..
Summary	116.46	....	2,958.12	......	100.0	265	165	66	29
Maximum	27.01	6.26	686.06	159.00	23.2	28	26	15	8
Minimum	2.53	....	64.26	......	2.2	15	9	1	0

Passing now to the subject of rainfall, the basis of fact is provided by the figures for the representative year of 1902, as given by Safford from Abbe's reductions; these are presented in somewhat modified from in table 3. As in the case of temperature, there is a long annual cycle with September as the month of greatest rainfall. The nadir of this cycle is not so clearly marked, but it occurs during the earliest months of the year. It is not proper to speak of a "dry" season in view of the fact that some rain was recorded on about half of the days during the months of less precipitation; the alternating seasons are the "wet" and the "less wet." The figures are exceptionally consistent; September is the month of greatest rainfall, it has the greatest number of days with more than 0.1 inch, of more than 0.5 inch, and of more than 1 inch, despite the fact that rain fell on 27 days as compared with the 28 days of August or July.

Without question local variations in precipitation occur, like regional fluctuations in temperature; the slopes of the mountains in the southern half of Guam receive much more rain than Agaña or the northern plateau. Yet the local variations must be far less in amplitude than in a large land-mass like Tahiti, for in Guam the mountains are not sufficiently high to prevent the heavier storms from passing over their peaks from the windward to the leeward side of the island.

Showers are so frequent as to diminish the effects of local differences in topography. During typhoon weather, when as much as 9 inches of rain may fall in 24 hours, the disturbance extends over such a wide area as to affect all parts of Guam to the same degree. Hence the figures for the station of record well serve to indicate the conditions of rainfall throughout the island and throughout the whole group.

VEGETATION.

In the Mariana Islands as elsewhere, snails of the genus *Partula* are inhabitants of the forests and thickets where there is a considerable amount of moisture; they are never found upon the grasslands or savannas of low or high altitude. The areas of their occurrence are thus directly determined by ecological circumstances of a botanical nature. The animals dwell upon the leaves and branches of trees, shrubs, and herbs, where they generally remain quiescent during clear daylight; at night and under the stimulation of rains during the day, they move actively about and seek the ground in order to feed. They eat dead and dying plant materials or humus, apparently for the sake of the fungoid growths which provide them with sustenance.

Quite as clearly as in the Society Islands, the intrinsic or specific characters of the plants with which Partulæ are associated are virtually indifferent; the indispensable requisites are that there shall be a sufficiently high and dense growth to provide shade, to conserve moisture, and to effect the production of a rich humus. Hence the limits to the areas occupied by Partulæ are set by the more ultimate ecological conditions which determine the distribution of suitable vegetation. A forest tree or shrub may harbor the animals, where a plant of the strand, similar in habit or identical in species, will be devoid of them. It is true that the animals of the Mariana Islands flourish in situations distinctly more open than the species of the Polynesian territory could tolerate, but aside from this qualification the general principles stated above hold true.

Safford's voluminous monograph enumerates the several types of botanical associations in Guam according to habitat, and it also specifies the characteristic members of each; this work is the basis for the following description. Although most of the distinguishable plant assemblages are utterly impossible as habitations for Partulæ, the comprehensive list is most valuable, as it serves to bring into clearer relief those which are entirely suitable. The items are here given in an altered sequence which places the habitable areas at the end, as follows: coral reefs, mangrove swamps, marshes, savannas, strand, inner beach, village environs, abandoned clearings, cliffs, river borders, and forests.

With the algal flora of the reefs and with the distinctive plants of the mangrove swamps we have no concern. The marsh plants include the reed *Trichoon*, the fern *Achrostichum*, and occasional trees such as the "hibiscus," *Pariti tiliaceum*, as well as the cultivated and native aroids, like the "taro" and "elephant-ear." The last-named is a form which may carry Partulæ in a suitable forest situation, but the snails are never found upon one in a marsh association.

The savannas are very interesting by virtue of their sharp contrasts with the forests in botanical respects, and also because they often abut directly upon the

A. Heights of Mt. Salifan, Guam. Savanna in foreground and bush above.

B. Contact of savanna and bush near the summit of Mt. Salifan, Guam.

bush of the uplands without a transitional zone (plate 4, A and B). Two types are characteristic of the savannas of the Mariana Islands, as in Polynesia; they are the sword-grass, *Xipheagrostis*, and the somewhat xerophytic fern *Gleichenia*. Typically there are no trees, but in the southwestern region especially the iron-wood, *Casuarina*, grows in some abundance, and sometimes beach shrubs like *Lobelia* casually establish themselves. The soil of the savannas is a red clay, very smooth and slippery during the rains and difficult to traverse on foot where the grasses are sparse. Such barren uplands occupy much of the territory in the southern half of Guam and constitute impassable barriers to the colonial interchange of snails dwelling in forested areas on their opposite sides; but much deforestation has been brought about, and undoubtedly the size and extent of the savanna barriers have increased during recent centuries.

The strand itself is relatively dry and sparsely inflorated. *Lobelia*, *Tournefortia*, *Casuarina*, with occasional *Pariti* and *Cocos*, constitute the higher growth, while *Ipomœa* and trailing legumes spread over the sandy ground (plate 5 A). The inner beach has a more ample growth of trees, including *Barringtonia*, *Terminalis*, *Pariti*, *Artocarpus calophyllum*, *Morinda*, and ficoids such as *Ochrosia;* although it is not listed by Safford, *Pandanus* often occurs among these associates. Among the shrubs of the inner beach are *Acacia*, *Ximenia*, and *Anona*. This type of assemblage often attains considerable density, and serves as an abode of Partulæ (plate 5 B).

Village environs are distinctly unfavorable by virtue of their open character; their plants are mainly introduced ornamental species, or are native types transplanted from their natural environments elsewhere. The abandoned clearings near former settlements, however, are frequently reoccupied by Partulæ from the forests, especially in northern Guam, when the new growth attains the proportions of a thicket (see plate 6 B). Various Leguminosæ are joined by shrubs such as the "lemoncito" (*Triphasia*) and by the breadfruit, *Pandanus*, *Pariti*, and the true *Hibiscus*. The main points of difference from the forest are the absence of trees of high growth and the scarcity of cycads.

The cliffs bear a limited series of plants upon their abrupt faces, which are sometimes populated from adjoining forests upon the plateau; this association is so limited as to require only a formal citation.

The flora of the river borders naturally varies greatly. Near the mouth of a stream like the Pago River or the Ylig River, the strand types occur together with other characteristic plants like the nipa palm. Further inland the hillsides may be open, and the savanna plants will come down very nearly to the river's edge. Or it may be that the valley bottom is covered by typical forests and thickets, in which case the snails will be quite as much at home as in the dense growth of a plateau far distant from a large stream.

The forests of low and high growth are the true homes of the Partulæ (plate 6 A), although the sparser thickets at their borders and in the reoccupied clearings often serve nearly as well, provided only that the rainfall and soil are favorable. It would be impossible to find a more comprehensive and complete description of the forest flora of Guam than that of Safford (*loc. cit.*, pp. 55, 56), which is herewith quoted with minor elisions:

The forest vegetation of Guam . . . consists almost entirely of strand trees, epiphytal ferns, lianas, and a few undershrubs. The majority of the species are included in what Schimper has called the Barringtonia Formation. The principal trees are the wild bread-fruit, *Artocarpus communis;* the Indian almond, *Terminalia catappa;* jack-in-the-box, *Hernandia peltata;* the giant banyan, . . . (*Ficus* sp.); two other species of *Ficus*, . . . ; *Pandanus fragrans* . . . and *Pandanus dubius*, two screw-pines which differ from many of their congeners in not being found growing on the outer beach; *Calophyllum inophyllum*, a handsome tree known in the East Indies as Alexandrian laurel . . ; *Barringtonia racemosa*, which, unlike its congener, *B. speciosa*, leaves the coast and follows along the streams into the interior; *Heritiera littoralis* . . . called in India the looking-glass tree . . . ; and, among recently introduced trees, *Canangium odoratum*, the fragrant flowers of which are the source of the perfume known as the ilangilang, *Annona reticulata*, the custard apple or bullock's heart, and *Pithecolobium dulce*, a leguminous tree known in the East Indies as the Manila tamarind . . . No truly indigenous palms occur, but *Areca cathuca*, the betel-nut palm, grows spontaneously in damp places; a small slender-stemmed species allied to Areca . . . is gradually spreading over the island; and the Caroline Island "sago-palm," *Cœloccocus amicarum*, has been introduced sparingly. Those familiar with the forest vegetation of Eastern Polynesia will be struck by the absence from the forests of Guam of such genera as Freycinetia, Papyrius (Broussonetia), Urticastrium (Laportea), Myristica, Parinari, Bocoa (Inocarpus), Dysoxylum, Nyalelia (Aglaia), Macaranga, Bischofia, Aleurites, Omolanthus, Spondias, Rhus, Alphitonia, Melochia, Kleinhovia, Metrosideros, Mæsa, and Diospyros.

Among the climbing plants and epiphytes of the forest are *Lens phaseoloides*, the scimitar-pod sea bean . . .; *Stizolobium giganteum* . . . ; a species of Calamus . . ; *Luisia teretifolia*, an inconspicuous orchid, and the minute leafless *Taeniophyllum fasciola; Dischidia puberula*, an interesting asclepiad growing upon trees . . . ; bird's-nest ferns (*Neottopteris nidus*), perched on the branches associated with broad ribbons of *Ophioderma pendula*, tufts of *Nephrolepis acuta* and *N. hirsutula*, grass-like *Vittaria elongata*, and pendent tassels of *Lycopodium phlegmaria* . . . ; climbing leathery-fronded *Phymatodes phymatodes*, lobed like oak leaves; *Cyclophorus adnascens*, with linear-lanceolate fronds; graceful *Davallia solida* . . . Tith glossy divided fronds, and the interesting *Humata heterophylla* . . .

Beneath the shade of the forest trees several undershrubs are usually found, including species of Icacorea, Piper, Peperomia, and the creeping rubiaceous *Carinta herbacea* . . . On the edges of the woods and by the roadsides are thickets of the spiny *Guilandina crista* . . . Lemoncito thickets (*Triphasia trifoliata*) are also common, the bushes sprouting from the roots and bearing fragrant, white, jasmine-like flowers and scarlet berries resembling miniature oranges. Among the succulent plants are wild ginger (*Zinziber zerumbet*), turmeric (*Curcuma longa*), *Canna indica*, the Polynesian arrowroot (*Tacca pinnatifida*), and the introduced *Tætsia terminalis*, a liliaceous plant with graceful tufts of red leaves. Besides the climbing and epiphytal ferns already mentioned there are many others growing on the ground, including *Belvisia spicata*, *Dryopteris dissecta*, *Dryopteris parasitica*, *Asplenium laserpitiifolium*, *A. nitidum*, *Microsorium irzoides*, and several species of Pteris. No filmy ferns (Hymenophyllaceæ) have been found on the island. The only tree fern of Guam thus far known is *Alsophila haenkei*, growing in damp places and often associated with *Angiopteris evecta*.

Cycas circinalis is also a striking and important element of the forest association; it thrives abundantly in the bush of the northern plateau and somewhat locally

A. Coast near Asan, Guam. Typical areas of bush and open slopes.

B. Outer Presidio area of collection, Guam. Close vegetation at the strand.

in the southern part of Guam as well. On Orote Peninsula, on Cabras Island, and in the Talofofo region, as mentioned by Safford, "the growth of Cycas trees, with their cylindrical scarred trunks and luxuriant fronds, strongly recall ideal pictures of the vegetation of the Carboniferous age, in which the Cycadaceæ formed so important a part" (*loc. cit.*, p. 253).

The foregoing detailed description of the forests clearly indicates the type of plant association in which Partulæ are found most abundantly. Additional features impress the observer, but they are secondary in value. For example, there are four general levels or "stories" in the thickest bush, namely, (1) the high trees, (2) the shrubs and *Pandanus*, (3) the cycads and taller ferns, and (4) the succulent herbs such as *Canna*, turmeric, and the like. Owing to extensive wood-cutting, the first named may be sparse or absent. The distinctions in question are involved in *Partula* ecology only to the extent that the highest story is not invaded by the animals, which prefer the levels nearer to the ground; by way of contrast, in the Society Islands *Partula attenuata* is confined to the highest branches and leaves of the lofty trees, while another species of Tahiti, *P. producta*, lives always on the ground. The types of Guam agree closely with the more typical Polynesian forms.

There is considerable variation in different places as regards the proportionate numbers of the component plants. In some instances, *Pandanus* will be dominant; in others, such as the Orote plateau, *Cycas* is the more abundant; while on Cabras Island, the ficoids constitute a far larger percentage than elsewhere. But the abundance of a particular kind of plant in no way determines the prevalence of a given species of *Partula*, or indeed the occurrence of any Partulæ whatsoever—a point that has been sufficiently discussed in the volume on the Tahitian species. Given the requisite amount of shade, of moisture, and of the humus for feeding, the animals will be found; specific botanical characteristics enter into the situation to the extent that a sufficiently thick growth can be constituted only by plants of suitable habits.

As regards the density of vegetation, one may distinguish about eight degrees of compactness, from the thick forest at one extreme to the thicket, the scattered clush of the plantation borders, the sparser growth of village environs and coastal bearings, finally to the treeless open ground of the "mesetas" or savannas. In the Mariana Islands, Partulæ have been found in regions of at least three degrees of density, namely, forest, thicket, and scattered bush, whereas the Polynesian species, in the author's experience, exist mainly in vegetation of the first or most dense degree, rarely exhibiting any tolerance of the thicket conditions, excepting in *P. hyalina* of Tahiti and the Cook Islands. A notable instance in the present group is that of the Chalankiya locality in Saipan, where as many as 30 partulæ were found on the under side of a single leaf of a caladium, growing in an area of the third degree of density (plate 9, A and B). In brief, then, the Mariana species are not so closely restricted to the forests remote from the sea as they generally are elsewhere; many times in Guam and Saipan, unusual numbers were collected from the thickets only a score of yards within the actual strand, or virtually at the water's edge itself (plate 5 B). Obviously the Mariana species differ constitutionally from the majority, as manifested by their existence in drier and more open situations.

FAUNA.

There are no other animals in the Mariana Islands whose presence or activities influence the lives or numbers of Partulæ, so far as observation goes. The shells in some of the species and varieties are brightly colored and consequently are quite conspicuous against the green of the vegetation; others are dull in coloration and are less distinct. As the various kinds differ markedly in their relative local abundance, it might be supposed that some animal enemies, also varying in their frequency, could be held accountable for the observed conditions; but not a single fact was noted in Guam or in Saipan which indicated that the snails were eaten by some carnivorous animal. If this does occur, it must be so rare as to be negligible in relation to the distribution of the diverse color-types of the species in the Mariana Islands.

Aside from the fruit-eating and insectivorous bats, no indigenous mammals occurred in the islands. Among the introduced species, only rats and mice might be enemies of the snails; but these animals frequent the settlements and plantations rather than the bush. While now and then in Tahiti a shell would be found that had been bitten by a rat, such specimens were never observed in the Mariana Islands, although Partulæ occurred in far greater relative abundance near the villages, where the rodents abound. Inland birds are few, and they are either insectivorous or frugivorous. A large lizard of the genus *Varanus* exists, which is an eater of birds and birds' eggs. The smaller lizards of the genus *Emoia* are very abundant even in the forests, but they seem to subsist entirely upon insects. Invertebrates are negligible in the present connection, unless, indeed, some of the lower parasites may prey upon the snails; if such is the case, the results would hardly be selective, in the sense that one color-variety would be more susceptible than another.

A. Characteristic vegetation serving as the most suitable habitation for Partulæ, Guam. (Published also in Natural History, Vol. 21, No. 2, 1921.)

B. Border of a thicket in Guam. Partulæ are present but not abundant in such situations.

CHAPTER II.

COLLECTIONS FROM GUAM AND SAIPAN.

ENDEMIC SPECIES OF PARTULA.

The Mariana Islands are inhabited by four species of the genus which occur nowhere else, in full accordance with the principle that each group of islands possesses its own characteristic forms; the previously known species are regarded by Pilsbry as sufficiently distinctive to justify their assignment to a separate section of the genus, MARIANELLA. Only the southern islands are ecologically suitable and, as the preceding chapter has shown, only certain portions of these islands are possible as habitations. The northern members of the group are relatively recent in their construction by volcanic agencies, and they are devoid of large land snails.

Prior to 1819 no Partulæ were reported by the scientific expeditions to the Ladrones.[1] In the year specified, the *Uranie* visited the islands, bearing the members of the de Freycinet expedition, among whom were the botanist Gaudichaud-Beaupré and the zoologists Quoy and Gaimard.

Partula gibba Férussac (1821) was collected by this expedition, and it is the most important among the Mariana species for the reason that it inhabits Tinian and Saipan as well as the larger island of Guam; it is not known whether it also occurs on Rota. A second species, *P. fragilis* Férussac (1821), is undoubtedly another discovery of the same expedition, for it is equally old in the literature; the describer gave no figures of the shell, and the species remained "lost" for decades. This is the form that was rediscovered by Quadras and it was described as *P. quadrasi* in 1894 by von Moellendorf, who, like Férussac, failed to give illustrations of his material. The observations of the present writer leave no doubt that the two authors had the same species in hand, and that therefore the older name must stand. The species inhabits Guam only, so far as is known, and it exists locally in that island. *Partula radiolata* Pfeiffer (1846) is next in seniority; it is not recorded outside of Guam, where it occurs in smaller numbers than *P. gibba*, and it is slightly less ubiquitous. *Partula salifana* is the fourth species, and it is a new discovery; it was found on the high vegetation near the summit of Mount Salifan—a somewhat remote peak in the southwestern part of Guam. In its isolation it is like *P. filosa*, which occurs in a portion of a single valley in the one island of Tahiti. From the foregoing review, it is clear that each species presents features of peculiar individual and comparative interest; each will be treated in a separate chapter, with the exception that *P. gibba* requires an independent analysis of its representatives in Guam and in Saipan.

AREAS OF COLLECTION IN GUAM.

A fundamental task of the present investigation is the exact determination of the places where distinguishable species and varieties existed at the time of the field-studies. From such basic facts of distribution, conclusions are hereinafter

[1] An account of the early scientific exploration of the Mariana Islands is given by Safford, *loc. cit.*, pp. 12–41.

drawn as to the relationships and recent migrations of the diverse types so distinguished. Thus the geographical and the biological elements of the situation as it is to-day will be established, to be available for the investigation of the same problems by some student of the future.

The collated facts of the preceding chapter show that the northern and southern halves of the island are somewhat sharply contrasted; the former is a relatively simple plateau with an extensive growth of vegetation suitable for Partulæ, while the southern part is mountainous and broken, and its areas of high vegetation are scattered and disconnected for the most part. The snails vary in different localities of the island, and hence the naïve conclusion would be that the local geographical and ecological differences are responsible for the biological differentiation of the organisms. While the contrary is the truth, nevertheless the geography of the areas of collection is indispensable for the description of the exact facts of distribution as well as for the discussion of the possibility that the "environment" is causal with respect to differentiation.

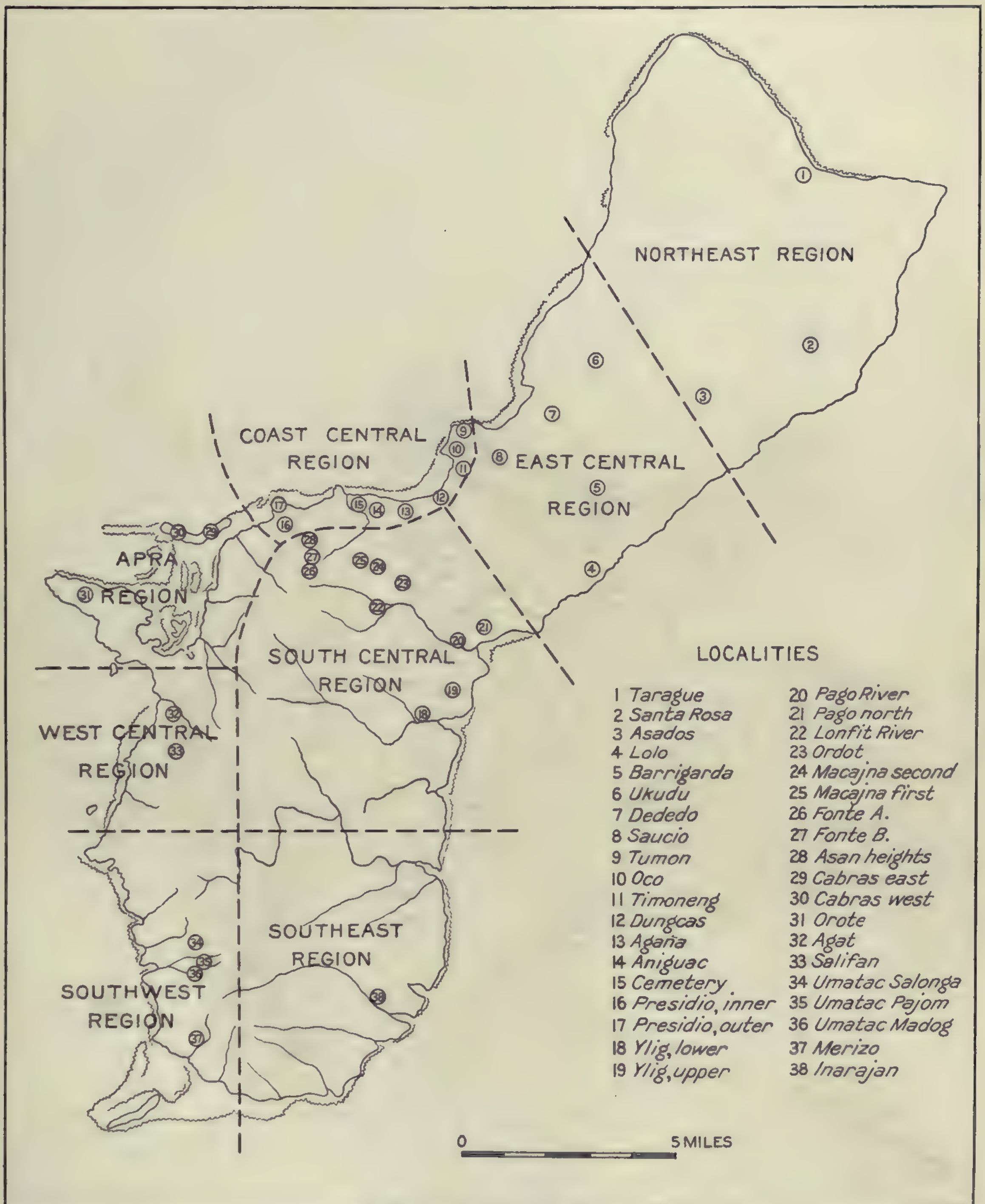
An ideal study of Guam, unhampered by limitations of time and energy, would divide the island into areas one mile square, and would determine the forms living in each of these component territories. While this procedure has not been possible, yet sufficient material was obtained from all of the various ecological districts for a detailed colonial analysis and for wide comparisons. In Saipan the areas of collection were limited to a series of eight stations on the western side of the island; while this material is less comprehensive, it proves to be valuable not only for the comparison with the identical species of Guam, but also because of its diversification, which is all the more remarkable in view of the small number of localities from which snails were obtained.

Partulæ were obtained from 39 localities of Guam, which are indicated in plate 7; while orthographic conventions differ, the names given are in current usage and clearly identify the places in question. These localities are representative of a series of districts into which the island may be arbitrarily divided for purposes of convenience and description.

The Northeast Region, so called, occupies the greater part of the extreme upper portion of the whole island; its vegetation is broken here and there by plantations and clearings, but for the most part it consists of typical forests, or of forests from which many of the highest trees have been cut. The Tarague collection was taken from the bush of the high plateau near the coast, while the snails from Santa Rosa and Asados represent the inland associations. The first-named locality was not visited personally, the collection being secured by a trustworthy assistant.

In the East-Central Region the Lolo locality is like Tarague above, Barrigarda is in line with Asados and Santa Rosa, while the collections from Ukudu, Dededo, and Saucio are typical of the populations of the western bush of the high limestone plateau. In ecological respects this region is virtually the same as the northeast region and is separated mainly for convenience.

What is distinguished as the Coast Central Region includes the localities of lower levels, from Tumon to the Presidio. At most of these places, the vegetation



Areas of collection in Guam.

is more sparse and of lower growth; on Tahiti no Partulæ at all would be found in such situations as the thickets of the outer Presidio (plate 5 B) or the bush back of the town of Agaña (plate 6 B).

The localities of the South Central Region are on the higher ground in almost all cases. Above Asan (plate 5 A) and above Fonte the vegetation is fairly thick, as on the northern plateau. The Macajna localities were situated on the lower slopes of the mountain of that name, with more open thickets of *Pandanus* and its associates. Near Ordot the snails were taken on almost isolated stands of *Pandanus*, or from the fringes of open thickets. At Pago North, so-called, the bush was thick and at least 200 feet above sea-level; the conditions in the case of the Upper Ylig locality were about the same. The Pago River and Lower Ylig collections were taken in the gorges of the respective streams at very low altitudes. Finally, the Lonfit locality was of intermediate level, adjoining the lower Pago on one side and the higher ground of the Ordot locality on the other.

Returning to the western side of the island, the Apra Region comprises three localities; two of these are areas of continuous vegetation on Cabras or Apapa Island, which is composed solely of rough, eroded limestone. The Orote locality is much higher, perhaps 400 feet above sea-level; its bush is like that of the northern plateau, but not quite so thick. The rock of the high Orote Peninsula is uplifted reef limestone. Otherwise in this region the bare westward slopes of the Tenjo ridge and the coconut plantations along the low borders of Apra Harbor are distinctly unsuitable as habitations of Partulæ.

In the West-Central Region the small Agat collection represents the thicket populations of low altitudes, as in the Coast Central localities. Here again it is noteworthy that no snails would be found under such circumstances in the Society Islands. On Mount Salifan the bush is thick near the summit, where it is isolated on all sides, except the south, by the extensive savannas or "mesetas" which occupy so much of the area of this whole region (plate 4, A and B).

Like the coastal areas of the Apra Region, the lower ground of the Southwest Region is not habitable (see plate 3, B and C). Only the higher levels above 300 feet altitude bear vegetation of a suitable growth, which rarely surpasses a thicket in density. Snails were secured at three places on the heights to the east of Umatac Bay, namely, Salonga, Pajom, and Madog. To the east of Merizo on the south coast, the valley of the Geus River cuts into the southwestern section of the mountain range, and here also the vegetation was relatively low and sparse. The locality is named from the adjacent village of Merizo.

The last region is the Southeastern. This is the territory which comprises the rolling eastward slopes of the high mountain ridge. Long river courses are cut in these slopes, and for the most part the habitable vegetation is restricted to the immediate neighborhood of such streams. The intervening ridges are bare savannas, or they possess a scanty growth of scrub and brush. Various circumstances prevented a personal visit to this region, but a series of snails was procured by a reliable assistant from the lower canyon of the Inarajan River. While a complete series of collections from all river gorges between Inarajan and the Ylig would be desirable, yet the material from the extreme localities mentioned is so similar as to render it probable that there is relatively little variation throughout the whole southeastern territory.

CENSUS OF THE COLLECTIONS, GUAM.

Nearly 4,000 adult snails of all species were collected in the entire series of localities, together with more than 1,500 immature individuals; the embryonic young and eggs dissected out of the bearing adults amounted to several thousand. The statistics given in table 4 record the varying absolute and relative numbers of the full-grown individuals, and the actual numbers of the adolescents as well.

In dealing with the returns, it must be kept in mind that the figures specify the actual numbers taken, and that their significance varies according to the size of the collection. A consistent effort was made to secure representative series of snails from a large number of typical localities, and at places like Tarague, Barrigarda, Lolo, and Fonte the results were entirely satisfactory from all standpoints. In other instances, the purpose was to ascertain whether any snails at all were living in a somewhat divergent ecological setting; cases in point are Timoneng, where the open thickets along the roadside were under inspection, and Agat, where, the village environs harbored snails under circumstances that would ordinarily be prohibitive. Again, as at Tumon, only a few passing minutes were given to determine whether both *radiolata* and *gibba* were present. At other times, a heavy tropical downpour or other climatic influence might shorten the time of field-work, with only a small representative collection in hand.

However, when all qualifications are made and all discounts allowed, certain general results emerge from the returns. It is unquestioned that *P. salifana* is sharply restricted in its habitat. Secondly, *P. fragilis* is local, for in spite of its wide ecological opportunities, it proves to be very scarce, except in the East Central Region; its occurrence in the Umatac area is quite extraordinary. *Partula radiolata* is less abundant relatively in the northern half of Guam, and more abundant in the same sense in the southern areas. Conversely, *P. gibba* exhibits exactly the opposite relationships.

Judgment as to the variation of a species as regards its actual abundance in different localities must be based partly on factors which do not appear in the table. It is inevitable that the weather conditions at the time of collection and prior to such time could not be identical, and as the animals are very respensive to changes in the weather, the numbers of snails would be different even if the same period of time were devoted to securing them at all places. In the subsequent chapters dealing with the several species individually, particular attention is given to the problem as to the real abundance of a species or variety as distinguished from its apparent or relative frequency.

COLLECTIONS FROM SAIPAN.

While the survey of Saipan was unavoidably incomplete, yet its main purpose was accomplished with the collection at eight representative localities of large numbers of *Partula gibba*, the only species of the genus known to exist on the island.

TABLE 4.—*Census of the collections, Guam.*

Locality.	Number of adults.					Per cent of adult population.				Number of adolescents.				
	Total.	*salifana.*	*fragilis.*	*radiolata.*	*gibba.*	*salifana.*	*fragilis.*	*radiolata.*	*gibba.*	Total.	*salifana.*	*fragilis.*	*radiolata.*	*gibba.*
Northeast Region:														
Tarague	355	...	1	62	292	......	0.3	17.4	82.2	128	...	...	8	120
Santa Rosa	68	...	...	......	68	......	.....	....	100.0	31	...	1	....	30
Asados	141	...	1	......	140	......	0.7	....	99.2	40	...	2	....	38
East Coastal Region:														
Lolo	226	...	...	2	224	......	.....	0.9	99.1	44	...	...	....	44
Barrigarda	223	...	13	23	187	......	5.8	10.3	83.8	81	...	11	7	63
Ukudu	80	...	3	4	73	......	3.7	53 0	91.2	32	...	1	....	31
Dededo	252	...	2	148	102	......	0.8	58.7	40.4	113	...	1	62	50
Saucio	75	...	1	62	12	......	1.3	82.6	16.0	39	...	3	32	4
Coast Central Region:														
Tumon	4	...	..	2	2	......	.....	50.0	50.0	6	...	3	....	3
Oco	29	...	13	2	14	......	44.8	6.9	48.2	17	...	12	2	3
Timoneng	18	...	...	2	16	......	.....	22.1	88.8	4	...	...	1	3
Dungcas	36	...	...	1	35	......	.....	2.8	97.2	17	...	...	1	16
Agaña garden	7	...	...	7	....	......	.....	100.0	......	3	...	...	3	.....
Agaña	32	...	...	3	29	......	.....	9.3	90.6	7	...	...	....	7
Aniguac	263	...	...	41	222	......	.....	15.6	84.4	99	...	...	36	63
Cemetery	42	...	...	3	39	......	.....	7.1	92.8	7	...	...	1	6
Presidio inner	66	...	...	1	65	......	.....	1.5	98.5	19	...	...	1	18
Presidio outer	56	...	...	23	33	......	.....	41.0	58.9	23	...	...	13	10
South Central Region:														
Ylig lower	204	...	...	204	......	......	.....	100.0	......	108	...	...	108	.....
Ylig upper	148	...	...	28	120	......	.....	18.9	81.1	128	...	...	36	92
Pago River	19	...	...	19	......	......	.....	100.0	......	10	...	...	10	.....
Pago north	123	...	...	52	71	......	.....	42.2	57.7	52	...	...	26	26
Lonfit River	43	...	...	26	17	......	.....	60.4	39.5	19	...	...	6	13
Ordot	74	...	...	45	29	......	.....	60.8	39.1	43	...	...	40	3
Macajna second	166	...	...	27	139	......	.....	16.2	83.7	56	...	...	13	43
Macajna first	18	...	...	2	16	......	.....	11.1	88.8	4	...	...	....	4
Fonte A	209	...	...	4	205	......	.....	1.9	98.1	15	...	...	4	11
Fonte B	94	...	...	18	76	......	.....	19.1	80.8	13	...	...	4	9
Asan heights	39	...	...	......	39	......	.....	....	100.0	10	...	...	1	9
Apra Region:														
Cabras east	112	...	...	112	......	......	.....	100.0	......	54	...	...	54	.....
Cabras west	69	...	...	69	......	......	.....	100.0	......	58	...	...	58	.....
Orote	149	...	...	130	19	......	.....	87.2	12.7	48	...	...	25	23
West Central Region:														
Agat	7	...	...	1	6	......	.....	14.2	85.7	1	...	...	1	.....
Salifan	118	19	...	13	86	16.1	.....	11.0	72.9	56	3	...	5	48
Southwest Region:														
Umatac Salonga	71	...	...	64	7	......	.....	90.1	9.8	37	...	...	35	2
Umatac Pajom	71	...	...	62	9	......	.....	87.3	12.7	37	...	...	30	7
Umatac Madog	153	...	2	144	7	......	1.3	94.1	4.6	39	...	1	34	4
Merizo	84	...	...	83	1	......	.....	98.8	1.2	36	...	...	35	1
Southeast Region:														
Inarajan	46	...	...	46	......	......	.....	100.0	......	51	...	...	51	.....
Summary by regions:														
Northeast	564	...	2	62	500	......	0.35	10.97	88.65	199	...	3	8	188
East Central	856	...	19	239	598	......	2.21	27.92	69.85	309	...	16	101	202
Coast Central	553	...	13	85	455	......	2.35	15.37	82.27	202	...	15	58	119
South Central	1,137	...	...	425	712	......	.....	37.38	62.62	458	...	...	248	210
Apra	330	...	...	311	19	......	.....	94.24	5.75	160	...	...	137	23
West Central	125	19	...	14	92	15.20	.....	11.20	73.60	57	3	...	6	48
Southwest	379	...	2	353	24	......	0.53	93.14	6.33	149	...	1	134	14
Southeast	46	...	...	46	......	......	.....	100.0	......	51	...	...	51	.....
Whole island	3,990	19	36	1,535	2,400	0.47	0.90	38.47	60.15	1,585	3	35	743	804

Despite the small number of areas under investigation, colonial variation is well displayed. As the Saipan material comprises the varieties of but a single species, to be dealt with separately in Chapter VII, the description of the areas of collection will be deferred to the later juncture.

METHODS OF TREATMENT AND ANALYSIS.

As the volume on the Tahitian species comprises a full description of the requisite routine methods, only a brief digest is given here for the sake of unity and completeness.

The animals were preserved in formalin, varying in strength from 2 to 5 per cent. They were first expanded by immersion in fresh water for a period of several hours, crowded closely in a closed glass jar; this treatment expands the bodies and renders them insensible. After they have been immersed in the preservative for several days, the greater part of the fluid may be poured off, thus lightening the jars for transportation.

Brought to the laboratory table, the material of a given locality is assorted into its component species, if more than one exists, and into the subordinate varieties. The qualitative and quantitative characters of the shells are then recorded, together with the data relating to the embryonic contents if any. The measured characters of the shells are (1) greatest length, including the lip, (2) greatest transverse dimension, also including the lip, (3) length of aperture, outside measure, and (4) width of aperture, outside measure. From these figures, the relative characters are determined, namely, (5) proportions of the whole shell, (6) proportions of the aperture, and (7) proportion of aperture length to the total shell length. Where a columellar tooth was present, its degree of development was noted according to an arbitrary scale. The colors of the outer surface of the shell, of the interior surface, of the apex, and lip were also precisely recorded.

The statistical methods are those of standard biometry. The average value of a character and the standard deviation are the essential figures for the collective description of a group of individuals. In comparing two associations on the basis of their respective constants, the probable errors must be taken into full account. A given difference must be at least three times its probable error in order to be fully indicative; if it is between two and three times its error, it is only probably significant, and if it is less than twice its error it is only possibly an indication of a real difference.

It remains to state that the author is personally responsible for the original measurements and for their mathematical reduction; therefore the personal coefficient is as uniform as it can be.

CHAPTER III.

PARTULA SALIFANA, new species.

The discovery of a new species of *Partula* was entirely unexpected, in view of the extensive investigations in Guam by such collectors as Quadras and Rush in recent decades, Garrett and Cuming a half-century ago, and Gaudichaud-Beaupré, Quoy and Gaimard, and Lesson in the earliest years of the scientific exploration of the Mariana Islands. So far as observation goes, the new form is sharply restricted to the summit of an isolated height in a remote and rarely visited part of the island; hence it is not excessively remarkable that the species has not been secured hitherto. It is a detail of interest perhaps that the novel snails were discovered in the course of the very last field trip in Guam to an area of relatively high bush on the summit of Mount Salifan which had attracted attention from a distance during other journeys about the coast. The ascent over the wet and slippery foothills was accomplished on the back of a carabao or water-buffalo, with an unusual amount of attendant discomfort and protracted after-effects.

The species is not abundant in its area of habitation; 19 adults in all were taken, together with 3 adolescent individuals, in an area of a few acres of bush growth just below the peak of Mount Salifan. The grown specimens constitute 16.1 per cent of the adult *Partula* population, their associates being the usual *gibba* and *radiolata* (see table 4). From the gravid snails, 26 eggs and 28 embryonic young were secured; the latter, like the partly-grown specimens, prove to be particularly valuable for the interpretation of the color characters of the species.

The requisite formal description is as follows: The shell is dextral, ovate-conic, with the spire somewhat protracted, and it presents the general appearance of the basic species of the Society Islands, in contrast with *gibba* and *radiolata* of its own island. The umbilicus is open and slightly flattened. In substance the shell is thick and heavy, again as in the Society Island species. The whorls are 5 to 5¼, slightly impressed below the suture. The embryonic whorls are closely engraved and their spiral lines are continued on the older whorls with wider spacing and lessening distinctness; about the umbilical depression at the base of the last whorl these lines are more deeply incised and more closely crowded. The mature cortex is smooth and shining, as if varnished. The color is a rich chestnut-brown or seal-brown, with a yellowish or olive cast in one specimen; as the result of decortication the color changes to purple, beginning with the apical whorls, and hence the general age of a shell is indicated by the extent of the purple modification. The extreme apex is deep purple in color in some instances. The interior of the last whorl is shining and purplish in color in all specimens. The aperture is elongated. The lip is well expanded and flattened, and its outer portion gradually narrows as it approaches its contact with the upper whorls; at the umbilical insertion it is broadly flattened and almost channeled. By the inward production of the lip the aperture is contracted to a noticeable degree. The color of the lip varies; in one specimen it is white, in the others it is pale yellowish brown, pale purplish, or both purple and yellow brown. A parietal tooth is entirely lacking. The foregoing diagnosis is rendered more concrete and precise by the illustrations (figs. 1 to 11, plate 11) and the tables (tables 5 to 8). Habitat: thick vegetation below the summit of Mount Salifan, Guam; altitude, 700 to 800 feet.

In the nature of the case, the locality where the new species was found is especially noteworthy. Mount Salifan is reported on the charts as over 800 feet in height, and it constitutes the northernmost member of the middle section of the mountain range in the western half of Guam. The highlands in question run approximately north and south with their crests from 1 to 2.5 miles inland from the coast. Between Salifan and the higher mass of Tenjo to the north the terrain is depressed, and like the slopes of Tenjo itself it is open savanna or meseta, bearing no high vegetation suitable for Partulæ. Thus *P. salifana* is cut off from the north by this wide barren zone, wherefore its absence from the collections taken in the northern half of Guam is entirely natural. The vegetation of its area is continued southward along the high ground leading ultimately to Mount Sasalaguan, but no specimens were secured from the southern localities actually explored. To the eastward again the vegetation is more or less continuous along the river courses cut into the long slopes on that side of the mountain range; whether or not *salifana* exists in such places could not be determined. Its presence on the heights south of Mount Salifan is more probable than in the areas of lower altitude along the eastern rivers.

The nurse plants are in no way unusual. Above the cogon grasses of the ascending slopes the bush begins abruptly at an altitude of about 700 feet and continues with few minor breaks to the summit (plate 4, A and B). Among the favored plants are the species of *Pandanus* which thrive here. Despite the seeming suitability of the conditions, only 118 adult snails of all species were taken by the author and his Chamorro companion, and this number is so small as to indicate a sparse Partula population in this region. Heavy rains had fallen during the two preceding days and nights, and on the day of the visit itself the skies were overcast and light rain was falling, thus permitting the snails to remain in more open situations—facts which still further emphasize the relative scarcity of the animals in this place.

A noteworthy general point is the similarity of *P. salifana* to the prevalent forms of the Society Islands and of other groups in Polynesia proper, which species are assigned by Pilsbry to the section *Partula sensu strictu*. The form of the shell and its heavier texture, exhibited even in half-grown examples, mark the resemblance in question and contrast *salifana* with the other Guam species which constitute the section MARIANELLA of Pilsbry. From another standpoint the thickness of the shell is very important, because it is a feature exhibited by a species which lives where no limestone rock is found; in the next chapter it will be pointed out that *P. fragilis* possesses a very thin shell and it thrives in the northern region of calcareous rock. Obviously in neither case does the soil's nature exert a direct effect upon the density of the shell.

The fundamental color of the species is chestnut-brown (figs. 1, 2, plate 11). 7 of the 19 specimens are typical in ground-color (figs. 2 to 4, plate 11), but they display more or less decortication of the first-formed whorls, which therefore become dull purple (fig. 3, plate 11); one of these shells possesses a deep purple apex by virtue of an actual pigmentation not shown in the others (fig. 4, plate 11). One individual among the non-decorticated adults differs in its peculiar yellowish-brown tinge verging toward olive-brown (fig. 1, plate 11). In 5 other specimens the color is deeper, approaching seal-brown, and all 5 exhibit much decortication; 2 have the unusual deep purple apex (fig. 5, plate 11). The remaining 6 shells are so decorticated as to be entirely light or dark purple, although small portions of the cortex may still persist in scattered areas (figs. 6 and 7, plate 11); 2 of these also have the deep apical pigmentation (fig. 7, plate 11). The various shades of the expanded lips are indicated by the illustrations and are systematically recorded in table 5. The smooth character of the original cortex is noteworthy.

TABLE 5.—*Partula salifana, Guam. Colors of lip and of embryonic young.*

Adults.	No.	Color of lip.					Embryonic young.			
		White.	Faint yellow-brown.	Yellow-brown.	Faint yellow-brown and faint purple.	More or less purple.	Faint light brown.	Yellowish-brown.	Brown.	Deep brown.
Olive brown	1	...	1	...	....	...	...	...	...	...
Chestnut brown, little or no decortication	7	...	4	...	3	...	2	4	2	...
Brown, partly decorticated	5	1	1	1	2	...	...	3	4	2
Brown, fully decorticated	6	...	1	...	3	2	...	4	6	1
Total	19	1	7	1	8	2	2	11	12	3

The three partly grown individuals are chestnut-brown of a much lighter cast on account of the relative thinness of their shells (figs. 8 and 9, plate 11). The apex is noticeably dark purple in two of these, but there is no indication of that kind of lighter color which comes only after maturity is attained and desurfacing ensues. Finally, in this connection we may note the colors of the embryonic young, 28 in number. Two are whitish with only a slight tinge of brown; 11 are light yellowish-brown (fig. 10, plate 11), and 12 are darker yellowish-brown. Three specimens are remarkable in their display of a deep-brown color quite as dark as that of the adolescents (fig. 11, plate 11). The statistical relations of the various kinds of young to their parents of the several color modes are given in table 5. The wall of the egg-capsule is transparent, and the albumen within is brown in color.

In summary, the very young shells gain their fundamental brown color in early or late embryonic life, and become darker as they grow older. During adolescence the full chestnut-brown develops and deepens to seal-brown in some cases. Subsequent decortication changes the whole shell to dull purple.

The statistical description of the perfect adult shells (table 6) precisely defines the seven standard characters of the new species in terms of the range, mean value, and standard deviation of each character. The data are also given for the classes of younger and older adults as distinguished by the absence or occurrence of decortication. The comparison reveals the fact that in the absolute measures of the whole shell and of the aperture, the former are slightly smaller; the explanation is that the lip continues to grow a very little after it is formed and reproductive maturity is gained.

TABLE 6.—*Partula salifana, Guam. Statistical description.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Range [class values]:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Non-decorticated...	7	17.15 – 18.65	10.50 – 11.10	57.5 – 62.5	9.70 – 10.30	6.85 – 7.15	68.5 – 70.5	53.5 – 58.5
Decorticated.......	10	17.75 – 18.95	10.50 – 11.70	57.5 – 62.5	9.90 – 10.90	6.85 – 7.45	67.5 – 71.5	54.5 – 58.5
All................	17	17.15 – 18.95	10.50 – 11.70	57.5 – 62.5	9.70 – 10.90	6.85 – 7.45	67.5 – 71.5	53.5 – 58.5
Mean value:								
Non-decorticated...	7	17.7929 ± .1255	10.8714 ± .0573	60.7857 ± .4246	10.0429 ± .0449	6.9929 ± .0330	69.2143 ± .2244	56.3572 ± .3713
Decorticated.......	10	18.2300 ± .0767	11.1000 ± .0809	60.9000 ± .4392	10.3600 ± .0715	7.2600 ± .0387	69.8000 ± .3171	56.8000 ± .2869
All................	17	18.0500 ± .1505	11.0059 ± .0628	60.8528 ± .3121	10.2294 ± .0550	7.1500 ± .0341	69.5588 ± .2134	56.6176 ± .2305
Standard deviation:								
Non-decorticated...	7	0.4924 ± .0887	0.2249 ± .0405	1.6659 ± .3002	0.1762 ± .0317	0.1294 ± .0233	0.8806 ± .1587	1.4569 ± .264
Decorticated.......	10	.3600 ± .0542	.3795 ± .0572	2.0591 ± .3105	.3353 ± .0505	.1814 ± .0274	1.4866 ± .2242	1.3453 ± .2028
All................	17	.9202 ± .1064	.3438 ± .0444	1.9079 ± .2207	.3365 ± .0389	.2086 ± .0241	1.3047 ± .1509	1.4093 ± .1630

In the nature of the case the estimate of the fecundity of this species rests upon observation of only a single colony. Taking the facts as they appear (table 7), the reproductive rate of *salifana* falls short of that of the more abundant species of the island. The contrast between the non-decorticated and the decorticated groups gives further evidence that the former are the more recently mature, because their rate of productivity is lower. The differences are not great, it is true, but they are consistent. The colors of the embryonic young (table 5) have already been discussed. They are all dextral in coil.

TABLE 7.—*Partula salifana, Guam. Statistics of fecundity.*

Series.	Records.	Gravid.	Per cent gravid.	Embryonic contents.			Average for gravid.	Average for all.
				Eggs.	Young.	Total.		
Non-decorticated.......	8	6	75	10	8	18	3.00	2.25
Decorticated...........	11	11	100	16	20	36	3.27	3.27
All................	19	17	89.46	26	28	54	3.18	2.84

By way of conclusion, it is interesting to compare *P. salifana* with *P. gibba* and *P. radiolata* of the same locality on the basis of the mean values or typical conditions of the several characters (table 8). The measures of the shell as a whole and the characters of the aperture show differences that are statistically significant in all instances, as judged by the probable errors of such differences. It is only in the last character, namely, the proportionate relations of aperture and shell, that *salifana* resembles the other two forms; the likeness is close in the case of *radiolata* but less marked in the case of *gibba*. This last character, however, proves to be almost generically constant as the studies of the species from the Society Islands have proved.

TABLE 8.—*Partula salifana, Guam, compared with P. gibba and P. radiolata of the same locality.*

	No.	Mean Value.						
		Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
P. salifana..	17	18.0500±.1505	11.0059±.0628	60.8528±.3121	10.2294±.0550	7.1500±.0341	69.5588±.2134	56.6176±.2305
P. gibba.....	86	17.3419±.0433	12.0651±.0338	69.6046±.1293	9.9488±.0286	7.3279±.0222	73.5930±.1287	57.3372±.1028
P. radiolata..	11	16.3045±.1557	10.4091±.0820	63.5000±.3420	9.3000±.0774	6.9182±.0473	74.1364±.2779	57.0556±.2586
P. salifana as compared with *P. gibba*.......		+0.7081±.1566	−1.0592±.0713	−8.7518±.3393	+0.2806±.0619	−0.1779±.0407	−4.0342±.2492	[−0.7192±.2524]
P. salifana as compared with *P. radiolata*....		+1.7455±.2161	+0.5968±.1033	−2.6472±.4641	+0.9294±.0949	+0.2318±.0583	−4.5776±.3504	[−0.4380±.3437]

CHAPTER IV.

PARTULA FRAGILIS Férussac.

The above-named species is rarely found except in portions of the northern half of Guam, and, even in the areas of its occurrence, its numbers are relatively few; hence its features of interest are quite different from those of *P. gibba* and *P. radiolata*, whose abundance, diversification, and wide distribution render them especially important. There are no figures of the shell of *fragilis* in the literature, but the circumstances are such as to leave no doubt that the material collected during the present research must be assigned to the species described by Férussac in 1821 as *P. fragilis*.[1] In 1894, von Moellendorf described the same species as *P. quadrasi*[2] from material collected by Quadras in Guam, but the earlier name and description must be accorded priority. Férussac's original diagnosis is translated as follows:

Shell ovate-elongate, perforate, fragile, striatulate, pellucid, reddish; spire obtuse, sutures strongly marked. Whorls 4, the last ventricose, subcarinate, larger than the rest. Aperture ovate, peristome subreflexed. Mariana Islands.

The description given by von Moellendorf is longer and more satisfactory in its detail; it is as follows:

Shell dextral, narrowly and half-covered perforate, rather ventricose ovate-conic, very thin, pellucid, delicately striatulate transversely, decussated by closely-crowded spiral lines; a little shining, pale buff variegated with narrow darker and whitish streaks, sometimes ornamented with two indistinct bands. Spire subregularly conic, the apex somewhat obtuse. Whorls 4, a little convex, separated by an appressed, marginated suture, the last whorl quite convex, nearly tumid. Aperture rather oblique, oval, a little excised; peristome simple, thin, well expanded, the columella dilated above, recurved, forming a distinct angle, almost channeled, with the parietal wall. Length 15, diameter 10.5, aperture 9 x 7 mm. Mariana Islands (Quadras).

Pilsbry comments as follows, on p. 318 of the *Manual:*

An unfigured species that seems to differ from the small form of *P. radiolata* in sculpture, and by having fewer whorls. It is possibly identical with Férussac's *P. fragilis*, a lost species which has not been figured.

Pilsbry's suggestion is correct, in my opinion. In the first place, the descriptions given by Férussac and von Moellendorf seem to refer to identical species of shells. Secondly, there can be no doubt that Quadras secured in Guam the specimens which von Moellendorf described and named in his honor. Thirdly, Gaudichaud-Beaupré is cited by Férussac as authority for the statement that *fragilis* was obtained at Guam; the same naturalist collected the first-known specimens of *gibba* during the visit to Guam of the de Freycinet expedition, likewise described by Férussac in 1821. The work of Gaudichaud-Beaupré bears ample evidence of his accurate powers of observation, and it is not likely that he would have made an error in the matter of the locality from which he obtained the shells of either species. Finally, the present writer's collections in Guam comprise a sufficient number of

[1] *Tableaux Systematique des Animaux Mollusques*, 1821, p. 66.

[2] Nachrichtsblatt der deutschen Malakologisches Gesellschaft, vol., xxvi, p. 15, 1894.

specimens to make it certain that *fragilis* and *quadrasi* are the same. It is unfortunate that neither of the two earlier authors published figures of the shells, for the type is peculiar and unmistakable, differing sharply from other species, even in the very young or adolescent condition.

Partula fragilis is interesting on many accounts, but above all on account of a character that is little short of astonishing; *it produces eggs and young snails before the parental shell attains the lip of the aperture as the conventional sign of its reproductive maturity.* No other species displays this feature, so far as my knowledge goes; it is so distinctive that it deserves all the prominence that can be given to it.

The total number of completely formed or "adult" specimens taken in all localities was 36, together with a single "dead" shell in the garden of Government House at Agaña, to which place it had undoubtedly been brought on a cluster of *Neottopteris* from some distant forest. The absolute and relative numbers of *P. fragilis* in the several localities and regions of Guam have been enumerated in the census table (table 4). The species seems to prefer the limestone table-lands of the northern part; it is absent from the ample collections taken in the central and eastern portions of the southern half. Its occurrence on the high ground of Umatac Madog possibly indicates some degree of climatic similarity between the northern plateau and the higher forested slopes of the volcanic mountains in the south.

The relative frequency of *fragilis* in the small collection from Oco is high, but this does not necessarily indicate a correspondingly great abundance in absolute numbers, in comparison with the situation at Barrigarda and elsewhere. Undoubtedly the center of the *fragilis* population is in the neighborhood of Oco; but the high percentage in question really signifies an interesting difference between *fragilis* and the associated forms in a physiological respect, namely, in its readier response to increased moisture and rainfall. When the visit was made to Oco the day was at first clear, hot, and dry; soon, however, a heavy tropical downpour occurred, and within a few minutes Partulæ emerged from the secluded places where they had taken refuge from the strong light. The *fragilis* individuals were quicker than *radiolata* and *gibba* in their responses to the changed conditions, and hence relatively more of their kind were taken. It is interesting in this connection to note that precisely similar observations were made in Huahine, a member of the Society Islands, when *P. arguta* and *P. annectens* behaved in the same way, in the restricted area about Tepare Valley, where only they exist.

Another character of *fragilis* worthy of special note is the pellucid quality of the shell. The soft body within is boldly maculated, and its pattern shows clearly through the semi-transparent shell. In this respect *fragilis* resembles young *P. clara* of Tahiti, *P. turgida* of Raiatea, and a few other species. Despite the fact that the favored habitat is the northern area, whose rock is calcareous, the shell is diaphanous and not influenced by the quality of the soil, either directly or indirectly; the specimens from the volcanic region of Umatac Madog are no lighter in weight, and, conversely, the associated *gibba* are no heavier in the limestone territories than they are on the volcanic heights. The quality of texture is clearly determined by congenital factors.

The statistical description given in table 9 comprises the figures for the entire series of "adult" shells taken in Guam, and also for the individual series from Barrigarda and Oco; only in the two places specified were enough snails secured to justify a statistical analysis. The obvious differences between the two colonies are manifested in the absolute width, and in the proportions both of the shell as a whole and of the aperture. The two shells from Umatac Madog are not unusual when compared with those of the north, saving only in the wider proportions of the aperture in one instance.

TABLE 9.—*Partula fragilis, Guam. Statistical description.*

	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Range (class values):		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Barrigarda.........	12	13.55 – 15.95	9.30 – 10.50	64.5 – 71.5	7.90 – 9.30	6.10 – 6.70	72.5 – 79.5	55.5 – 59.5
Oco..............	13	12.95 – 15.35	8.50 – 10.10	63.5 – 70.5	7.30 – 9.10	5.70 – 6.70	73.5 – 77.5	55.5 – 60.5
Whole series........	36	12.95 – 15.95	8.50 – 10.70	63.5 – 73.5	7.30 – 9.50	5.70 – 7.10	70.5 – 80.5	55.5 – 62.5
Mean value:								
Barrigarda.........	12	14.4000 ± .1062	9.8000 ± .0863	67.8333 ± .4921	8.3333 ± .0671	6.3500 ± .0424	76.2500 ± .4363	57.6666 ± .1920
Oco..............	13	14.1346 ± .1625	9.4693 ± .0938	66.4231 ± .3153	8.2077 ± .0825	6.2077 ± .0478	75.5000 ± .2645	57.8846 ± .2492
Whole series........	36	14.4000 ± .0847	9.7722 ± .0590	67.7778 ± .2684	8.3555 ± .0496	6.3444 ± .0356	75.9444 ± .2519	57.9722 ± .1644
Standard deviation:								
Barrigarda.........	12	0.5454 ± .0751	0.4435 ± .0610	2.5276 ± .3479	0.3448 ± .0474	0.2179 ± .0300	2.2407 ± .3085	0.9860 ± .1357
Oco..............	13	.8685 ± .1149	.5014 ± .0663	1.6853 ± .2229	.4411 ± .0583	.2556 ± .0338	1.4142 ± .1870	1.3324 ± .1762
Whole series........	36	.7533 ± .0599	.5253 ± .0417	2.3876 ± .1898	.4412 ± .0351	.3166 ± .0252	2.2414 ± .1781	1.4622 ± .1162

TABLE 10.—*Partula fragilis, Guam. Color classification.*

Locality.	Number of "adults."	Color-classes of "adults."			Number of "adolescents" (buff).
		Darker buff.	Buff.	White.	
Northeast Region:					
Tarague...............	1	..	1	..	..
Santa Rosa............	0	..	..	..	1
Asados................	1	1	..	..	2
East Central Region:					
Barrigarda............	13	6	6	1	11
Ukudu.................	3	2	1	..	1
Dadedo................	2	2	..	..	1
Saucio................	1	1	..	..	3
Coast Central Region:					
Tumon.................	0	..	..	..	3
Oco...................	13	10	1	2	12
Agaña, garden.........	*[1]	..	[1]	..	..
Southwest Region:					
Umatac Madog........	2	2	..	..	1
Total.............	36	24	9	3	35

* "Dead shell."

Originally the color of the shell is corneous buff, with close strigations of yellowish brown and lighter buff. Even in quite young individuals, the shining cortex wears away, beginning at the apex, thus leaving the whitish substratum exposed. Although the total range of coloration is much restricted, three color-classes may be distinguished, as darker buff, buff, and white, whose varying numbers in the collections from the several localities are given in table 10. The second of these is the central color group, because all of the adolescents are of this kind (adults, figs. 13 and 15; adolescents, figs. 17 and 18, plate 11). By subsequent darkening, and especially by the widening of the darker transverse streaks, the first-named color form is produced (fig. 12, plate 11). Decortication throughout leaves the entire shell white (figs. 14 and 16, plate 11), save for the minute patches of cortex which still adhere irregularly over the surface.

A parietal tooth is never formed, and not even a trace of this structure has been observed in the shells which provide the basis for the present account.

On a close examination of the snails of various ages, the astounding discovery was made that reproductive ability was manifested by individuals whose shells had not yet formed the flaring lip which is elsewhere the sign of maturity. The statistics of fecundity (table 11) have a peculiar interest in this case. They show a relatively low rate of productivity as compared with other species; yet every "adult" snail wherever found was gravid. Among the "adolescents" whose shells measured over 12 mm., 13 out of 15 were also gravid and their collective rate of fecundity proved to be only slightly less than that of the snails with completed shells. Individuals below 12 mm. in length were uniformly barren.

TABLE 11.—*Partula fragilis, Guam. Statistics of fecundity.*

Series.	Records.	Gravid.	Embryonic contents.			Average for gravid.
			Eggs.	Young.	Total.	
"Adults":						
Barrigarda	13	13	17	1	18	1.38
Oco	13	13	23	1	24	1.84
Whole series	36	36	56	6	62	1.72
"Adolescents":						
Over 12 mm	15	13	17	5	22	1.69
Total	51	49	73	11	84	1.71

The shells of the embryonic young (fig. 19, plate 11), attain a length of 4 mm. before the animals emerge to the outer world. The eggs possess a tough capsule, *fully impregnated with calcareous salts;* and in this latter respect *fragilis* differs from all other species of Guam. In their great size, the eggs of this species are also unique; the length is about 4.2 mm. and the transverse diameter is 3.3 mm. One partly-grown individual with a shell 12.9 mm. in length, contained one young snail and two eggs whose combined lengths were 11.5 mm.—truly an astonishing bulk for the reproductive products of so small a snail.

CHAPTER V.

PARTULA RADIOLATA (Pfeiffer.)

GENERAL CONSIDERATIONS.

Partula radiolata (Pfeiffer) exists in considerable numbers in the island of Guam, where it is widely distributed as well; furthermore, it varies from place to place throughout the island, with the result that individual associations differ mutually as regards the average size and form of the shells, and also as regards the kinds and relative abundance of their component color-classes. For these reasons *Partula radiolata* is available for the detailed study of variation and geographical distribution and consequently it is far more valuable than *salifana* and *fragilis*, although the two forms described in the foregoing chapters are most interesting in other connections. The present species approaches but does not equal the remaining form, *P. gibba*, in its abundance and diversification throughout the island.

The taxonomic history of *radiolata* is relatively clear. The original shells were named *Bulimus* (*Partula*) *radiolatus* by Pfeiffer in 1846,[1] and they were certainly obtained by Cuming, for the title of Pfeiffer's communication explicitly credits them to that noted collector. Subsequently in 1849, Pfeiffer renamed the species correctly as *Partula radiolata*. In the original account the habitat is given as New Ireland, an island of the Bismarck Archipelago later called New Mecklenburgh; a similar error is perpetuated in Hartman's list of 1881[2] with the citation of Cox as the authority; but Cox himself corrected the mistake and properly referred the species to Guam in a letter to Hartman quoted by Smith.[3]

In view of the abundance of *radiolata* at the present time and its unquestionable occurrence in some numbers about 1840, it is surprising that it was not recorded from the material collected by Gaudichaud-Beaupré which was described by Férussac, and which comprised *gibba* and *fragilis* as well, the latter being a species that is far less abundant than *radiolata* at the present time. On general grounds one would suppose that the pioneer naturalists did indeed secure specimens of *radiolata* which were lost, or were referred erroneously to other localities, or most probably were not properly distinguished from their associates living in Guam. The last possibility seems actually to be the truth. Quoy and Gaimard were members of the Freycinet expedition of 1819, and returned to Guam as members of the *Astrolabe* expedition in 1828. In their account of their zoological observations[4] they deal at some length with *Partula gibba* under the name of *Helix gibba*, repeating Férussac's original description and adding their comments on the animal and its habits. It seems certain that they had some specimens of *radiolata* in hand, for they write of a "Varietas, elongata, subflava, longitrorsum albo notata; peristomate ovali et albo"; and later they wrote: "La variété que nous figurons, et qui est assez rare, se distingue par son plus grand allongement, par son overture assez régulièrement ovulaire, son péristome blanc, sa couleur jaune clair, marquée

[1] L. Pfeiffer, Proc. Zool. Soc. London, part xiv, p. 39, 1846.
[2] W. D. Hartman, Bul. Mus. Comp. Zool., vol. ix, No. 5, p. 186.
[3] H. H. Smith, Annals Carnegie Museum, vol. 1, 1902, p. 439.
[4] Quoy and Gaimard, *Voyage de l'Astrolabe, 1833*, Tom. 2, pp. 113–115, plate 9, figs. 18–22.

de stries blanchâtres plus intenses sur le dernier tour." While their figures 18, 19, and 20 are undoubtedly *gibba*, those numbered 21 and 22 clearly represent the species named *radiolata* by Pfeiffer at the later date specified. Presumably, then, the shells denoted a "variety" by Quoy and Gaimard were collected by them when they visited Guam as members of the *Astrolabe* expedition and not during their earlier visit with the Freycinet expedition; hence the specimens in question did not come into the hands of Férussac, who would assuredly have recognized their specific distinctions.

Garrett visited Guam during the last quarter of the nineteenth century, but it is uncertain whether he collected specimens of *radiolata* as he did of *gibba*, for the evidence on this point is conflicting.[1] Finally Quadras and Rush are named in Pilsbry's *Manual* as the collectors of distinguishable subordinate forms of this species.

The original description by Pfeiffer, translated in Pilsbry's *Manual* (p. 316) is as follows:

Shell subperforate, oblong-tapering, the apex obtuse, thin; sculptured with distant impressed spiral lines; pale straw-colored, rayed with darker streaks and brown lines. Whorls 5, slightly convex, the last about equal to the spire, base tumid in front. Columella short, shortly receding. Aperture obliquely oval, glossy inside, yellow; peristome simple, thin, white, expanded, the right margin somewhat straightened, columellar margin dilated above, spreading above the umbilicus. Length 19, diam. 10, aperture 9 by 5 mm. inside.

Pfeiffer refers to a variety "testa carnea, radiis cinnamomeis," which is a well-marked color-form existing in certain localities. No other supplementary diagnoses have been given since Pfeiffer's time, except in the case of the variants mentioned by Pilsbry as collected by Quadras and Rush respectively; the last-named is distinguished as *P. radiolata rushii*, but in my own opinion it is entitled to the status of a color-form only, and not to full varietal standing.

At this juncture it is well to add the important fact that the parietal tooth of many other species is universally lacking in *radiolata*. Another character of much interest is the transparent nature of the egg-capsules, which are entirely devoid of calcareous impregnations from their earliest formation.

In the course of the present investigation, 1,535 adult specimens and 743 adolescents of *radiolata* were collected in most but not all of the 39 localities of Guam where Partulæ were secured; the gravid adults yielded 1,909 young and 3,502 earlier embryos denoted "eggs." Thus there is sufficient material for a detailed quantitative description which substantially amplifies the qualitative accounts given by earlier authors. This description is concerned with the specific characters of *radiolata* and their variation, and with the collective or colonial diversification displayed by the associations of different areas, as regards the basic qualities of shell structure and coloration as well as the lesser but by no means negligible matter of numerical abundance.

[1] cf. Smith, *loc. cit.*, pp. 176, 480.

VARIATION IN NUMERICAL FREQUENCY.

In the volume of the Partulæ of Tahiti, the significance of variations in numerical abundance was discussed at considerable length in the case of *P. hyalina*, taken as a representative species, and more briefly in the chapters of the other species of that island. In the present connection a succinct statement will suffice, as the facts are identical in character and their significance is the same in principle.

Partula radiolata occurs almost everywhere in the island where suitable vegetation exists; it is sometimes abundant and sometimes scarce in regions that are ecologically identical as far as the evidence goes. Apparently it is the innate congenital vigor of the members of a given association that determines their numerical abundance. Where no suitable vegetation exists, the species can not live; otherwise there seems to be no direct relation between the ecological diversification of Guam and variations in the colonial frequency of *radiolata*, or indeed of any other species.

The general census table given in Chapter II (table 4) shows the absolute and relative numbers of *radiolata* in the several localities where collections were made. Clearly the figures of relative frequency must be regarded as approximations where only a few snails were taken, owing to their actual scarcity or to transitory adverse conditions at the time of the survey, such as drought, shortness of the time in the field, and the like. Then, also, relative abundance is determined in part by the actual numbers of the other *Partula* associates of the same locality. If the time devoted to field collection were the same in all places, and if the circumstances of moisture, heat, and density of vegetation were identical in all instances, then and only then would the figures be entirely trustworthy at their face values; obviously it is virtually impossible to fulfill these conditions.

Yet when all allowances are made, certain interesting facts emerge from the returns, and a somewhat definite conclusion is reached. The northern (or northeastern) half of Guam is practically uniform in its ecology, while *radiolata* is actually as well as relatively scarce in the eastern areas and more abundant in the western portion. A comparison of the collections from Santa Rosa, Asados, and Lolo with those from Dededo and Saucio discloses this point. But in the southern (or southwestern) half of the island, *radiolata* is quite as abundant in the inhabited areas to the east as it is on the west, although the scarcity of *gibba* obscures this fact. The point is that the paucity of specimens in the eastern half of the northern portion can not be referred to climatic conditions, for these are the same in the eastern half of the southern territory where the species flourishes.

Cabras Island bears only *radiolata*, which, however, is not actually more abundant than in places on the mainland, for as a matter of fact the numbers secured here in a given time were smaller than elsewhere. The ecological conditions of Cabras are not especially favorable for *radiolata* and adverse for other species like *gibba;* the truth of the matter is that *gibba* is absent owing to its inability to reach the detached area by migration from the larger land-mass, or to its complete disappearance from Cabras, assuming that it was present in earlier times.

In the Southwest and Southeast Regions *radiolata* forms the major and almost the exclusive population, owing to the scarcity of *gibba*. The figures for Inarajan, Lower Ylig, and the Pago River are especially interesting because the areas of collection were the lower levels of the respective valleys, where *gibba* either does not occur at all or is very rarely found. On the higher ground of the Upper Ylig locality, Pago North, and across the island at Macajna and Fonte, *radiolata* is less abundant, actually and relatively as well, for *gibba* thrives plentifully at the latter places. But the Dededo region extends at approximately the same level as the Macajna, Fonte, and Barrigarda localities. It is not permissible, therefore, to draw the conclusion that the present species is generally more abundant at lower than at higher levels; hence the barometric factor is also to be discarded as conditioning the numerical frequency of the species.

The character of the soil is likewise a matter of indifference. In the suitable areas of vegetation in the Umatac territory, where the ground is volcanic in earlier origin, *radiolata* lives quite as well as in similar situations in the northern half of Guam, where the rock is uplifted reef limestone.

In summary, therefore, we can only say that the numbers of *radiolata* are sometimes many, where conditions seem to be favorable, and sometimes few where the circumstances appear to be identical. In any locality which possesses the prime requisites of vegetation and moisture, the actual numerical abundance of the species appears to depend primarily upon the innate vigor and reproductive rate of the organisms.

COLONIAL VARIATION IN QUANTITATIVE CHARACTERS.

We now come to the detailed consideration of the variations displayed by the representative collections of *radiolata* secured in the several localities of Guam. When the whole field is broadly surveyed, the colonial series differ not only in the matter of the density of population, but much more fundamentally in the statistical constants that accurately describe the measurable characters of their shells. Such differences are quite independent of variations in color composition, in which two modes occur, inasmuch as the colonies vary as regards the *kinds* of color types that are present as well as in the *relative numbers* of the component color-classes. No collection from a given locality, ample enough to be truly representative, is exactly similar to that from another place; where the comparable series are small, the differences are naturally accentuated. The degrees of difference vary, and they are sometimes great in one respect, while they are nearly or entirely negligible in others; but there are no exceptions to the general rule. Furthermore, no observable relation exists between an ecological factor, like the nature of the soil or the numbers of a particular nurse-plant, and the distinctive qualities of a given association, whether of size or shape or coloration of the shells.

The complete description of the shell characters is given in tables 12 to 14, which comprise the figures for the individual associations which are sufficiently large to warrant the labor of their statistical analysis, for the assembled regional populations, and for the whole collection. The extreme ranges of the characters (table 12) are given in terms of the class values and not of the absolute measurements. The mean values and the standard deviations are the fundamental descriptive constants of the curves of variation of the several associations and of the more comprehensive groupings. The consecutive order is somewhat misleading,

TABLE 12.—*Partula radiolata, Guam. Statistical description: range of the fundamental characters.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Northeast Region:								
Tarague	58	14.15 – 18.65	9.1 – 11.5	56.5 – 65.5	8.5 – 10.5	6.3 – 7.7	69.5 – 77.5	52.5 – 60.5
East Central Region:								
Barrigarda	22	15.35 – 19.25	9.5 – 11.9	58.5 – 68.5	8.5 – 10.7	6.3 – 7.9	67.5 – 76.5	54.5 – 60.5
Dededo	144	14.45 – 18.65	9.3 – 11.3	57.5 – 69.5	8.5 – 10.5	6.3 – 7.5	67.5 – 79.5	52.5 – 61.5
Saucio	57	15.05 – 18.35	9.1 – 10.9	57.5 – 65.5	8.3 – 10.1	6.1 – 7.5	70.5 – 77.5	51.5 – 58.5
Whole region[1]	228	14.45 – 19.25	9.1 – 11.9	56.5 – 69.5	8.3 – 10.7	6.1 – 7.9	67.5 – 79.5	51.5 – 61.5
Coast Central Region:								
Aniguac	37	15.35 – 18.05	9.5 – 11.3	56.5 – 66.5	8.9 – 10.5	6.1 – 7.5	67.5 – 75.5	54.5 – 60.5
Presidio, outer	22	16.25 – 18.35	10.3 – 11.5	59.5 – 69.5	9.1 – 10.1	6.7 – 7.7	70.5 – 76.5	53.5 – 59.5
Whole region[1]	78	15.35 – 18.35	9.5 – 11.5	56.5 – 69.5	5.4 – 10.5	6.1 – 7.7	67.5 – 76.5	53.5 – 60.5
South Central Region:								
Ylig, lower	193	15.65 – 18.95	9.3 – 11.3	55.5 – 64.5	8.5 – 10.5	5.9 – 7.3	65.5 – 77.5	50.5 – 59.5
Ylig, upper	25	15.95 – 18.65	9.9 – 10.9	55.5 – 65.5	8.9 – 10.5	6.3 – 7.3	68.5 – 76.5	52.5 – 57.5
Pago River	17	15.65 – 18.65	9.3 – 10.9	57.5 – 62.5	8.7 – 10.1	6.3 – 7.3	68.5 – 73.5	52.5 – 58.5
Pago, North	43	15.05 – 18.65	9.3 – 11.1	57.5 – 65.5	8.5 – 10.3	5.9 – 7.3	68.5 – 77.5	50.5 – 59.5
Lonfit	24	15.65 – 18.35	9.3 – 10.5	56.5 – 65.5	8.5 – 9.9	5.9 – 7.1	67.5 – 73.5	53.5 – 60.5
Ordot	43	15.05 – 18.05	9.5 – 11.1	57.5 – 64.5	8.5 – 10.1	6.3 – 7.3	69.5 – 76.5	51.5 – 59.5
Macajna	25	15.35 – 17.15	9.5 – 10.5	58.5 – 65.5	8.7 – 9.9	6.3 – 6.9	68.5 – 74.5	53.5 – 60.5
Fonte	21	14.75 – 17.45	8.7 – 10.3	57.5 – 62.5	8.5 – 9.5	6.1 – 6.9	67.5 – 74.5	54.5 – 59.5
Whole region	391	14.75 – 18.95	8.7 – 11.3	55.5 – 65.5	8.5 – 10.5	5.9 – 7.3	65.5 – 77.5	50.5 – 60.5
Apra Region:								
Cabras, east	105	14.15 – 17.75	8.3 – 10.7	55.5 – 65.5	7.7 – 9.7	5.5 – 7.1	69.5 – 77.5	50.5 – 58.5
Cabras, west	69	13.85 – 16.85	8.5 – 10.7	57.5 – 65.5	7.9 – 9.3	5.7 – 7.3	69.5 – 81.5	51.5 – 59.5
Orote	128	13.55 – 17.45	8.5 – 10.7	56.5 – 68.5	7.7 – 9.5	5.3 – 6.9	66.5 – 76.5	50.5 – 61.5
Whole region	302	13.55 – 17.75	8.3 – 10.7	55.5 – 68.5	7.7 – 9.7	5.3 – 7.3	66.5 – 81.5	50.5 – 61.5
West Central Region:								
Salifan	11	15.65 – 18.35	9.9 – 11.5	60.5 – 66.5	8.9 – 10.3	6.7 – 7.5	71.5 – 75.5	55.5 – 59.5
Southwest Region:								
Umatac Salonga	53	15.35 – 18.95	9.5 – 11.7	56.5 – 65.5	8.7 – 10.7	6.3 – 7.9	68.5 – 76.5	52.5 – 61.5
Umatac Pajom	55	15.35 – 18.95	9.5 – 11.5	55.5 – 65.5	8.7 – 10.5	6.3 – 7.9	67.5 – 76.5	53.5 – 60.5
Umatac Madog	133	15.05 – 20.45	9.3 – 12.1	55.5 – 67.5	8.3 – 11.3	5.9 – 7.9	66.5 – 77.5	49.5 – 61.5
Merizo	69	15.95 – 18.65	9.5 – 11.7	56.5 – 67.5	8.5 – 10.5	6.3 – 7.5	67.5 – 76.5	51.5 – 60.5
Whole region	310	15.05 – 20.45	9.3 – 12.1	55.5 – 67.5	8.3 – 11.3	5.9 – 7.9	66.5 – 77.5	49.5 – 61.5
Southeast Region:								
Inarajan	38	14.15 – 17.45	8.5 – 10.5	58.5 – 65.5	8.3 – 9.9	5.7 – 7.1	67.5 – 77.5	53.5 – 60.5
Whole island	1416	13.55 – 20.45	8.3 – 12.1	55.5 – 69.5	7.7 – 11.3	5.3 – 7.9	65.5 – 81.5	49.5 – 61.5

[1] Including the smaller local collections.

because the several localities are not arranged serially around the island like the areas of investigation in Tahiti; but it is impossible to devise a tabular order which will indicate how a given community is to be compared with a number of others situated in different directions with reference to it, as, for example, Macajna in relation to Fonte, Agaña, Ordot, and Lonfit.

The tables describe 23 associations quantitatively, while 11 are omitted, mainly because they comprised too few individuals, although these are included in the proper regional and complete groupings. It is true that the series from such places as Salifan, outer Presidio, and many localities of the South Central Region

TABLE 13.—*Partula radiolata, Guam. Statistical description: mean values of the fundamental characters.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Northeast Region:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Tarague	58	17.1965±.0665	10.5517±.0376	61.3966±.1658	9.6896±.0380	7.0724±.0260	72.7586±.1657	56.2414±.1532
East Central Region:								
Barrigarda	22	16.5637±.0887	10.4455±.0795	62.5454±.3226	9.5363±.0686	6.9182±.0581	72.3636±.3135	57.2273±.1899
Dededo	144	16.4583±.0433	10.3625±.0216	62.8403±.1260	9.4653±.0213	6.8584±.0157	72.3611±.1113	57.4792±.0986
Saucio	57	16.5237±.0626	10.1982±.0294	61.4293±.1824	9.2017±.0333	6.7913±.0278	73.6930±.1626	55.4649±.1524
Whole region[1]	228	16.5197±.0339	10.3325±.0177	62.4298±.1008	9.4079±.0181	6.8465±.0135	72.6667±.0923	56.9123±.0854
Coast Central Region:								
Aniguac	37	16.9311±.0654	10.5216±.0469	61.9865±.2197	9.7054±.0474	6.9324±.0359	71.5811±.2354	57.0135±.1538
Presidio, outer	22	17.1909±.0836	10.9636±.0462	63.9546±.3178	9.7182±.0424	7.1818±.0343	73.5000±.1987	56.7283±.2076
Whole region[1]	78	17.0077±.0494	10.5872±.0361	62.2051±.1847	9.6718±.0317	6.9641±.0246	71.9231±.1661	56.6923±.1147
South Central Region:								
Ylig, lower	193	17.1609±.0326	10.2824±.0186	59.8731±.0865	9.3964±.0179	6.6492±.0130	70.5829±.0899	54.6554±.0666
Ylig, upper	25	17.2220±.0959	10.4440±.0393	60.7000±.2777	9.4840±.0539	6.7560±.0345	71.1400±.2695	54.9800±.2162
Pago River	17	16.9912±.1079	10.1588±.0751	59.5888±.2476	9.3470±.0630	6.7235±.0487	71.7941±.2494	54.9117±.2513
Pago, north	43	16.7035±.0906	10.2767±.0500	61.5000±.1934	9.3930±.0495	6.7325±.0343	71.5697±.1951	56.2442±.1935
Lonfit	24	16.5250±.0891	9.9166±.0556	59.9583±.1104	9.2250±.0532	6.5750±.0392	70.8750±.1939	55.8333±.2000
Ordot	43	16.9267±.0577	10.3651±.0303	61.2442±.1789	9.4209±.0352	6.8814±.0225	72.8721±.1856	55.6628±.1536
Macajna	25	16.1780±.0599	10.0760±.0458	62.2200±.1967	9.3240±.0392	6.6760±.0273	71.5800±.2130	57.4200±.2130
Fonte	21	16.1214±.0872	9.6810±.0517	60.3572±.2141	8.9857±.0447	6.4333±.0285	71.4048±.3071	55.8809±.1436
Whole region	391	16.9183±.0122	10.2279±.0143	60.4233±.0657	9.3650±.0133	6.7205±.0096	71.1573±.0671	55.2877±.0573
Apra Region:								
Cabras, east	105	15.6472±.0458	9.4524±.0266	60.3095±.1246	8.5038±.0247	6.2200±.0193	72.9381±.1023	54.1572±.0998
Cabras, west	69	15.3645±.0594	9.4391±.0347	61.3551±.1384	8.5319±.0300	6.2681±.0237	73.1377±.1354	55.3841±.1372
Orote	128	15.4203±.0309	9.4806±.0292	61.4531±.1309	8.6265±.0255	6.1953±.0199	71.8125±.1082	55.8906±.1218
Whole region	302	15.4861±.0307	9.4656±.0177	61.0331±.0799	8.5623±.0156	6.2205±.0121	72.5596±.0752	55.1722±.0757
West Central Region:								
Salifan	11	16.3045±.1557	10.4091±.0820	63.5000±.3420	9.3000±.0774	6.9182±.0473	74.1364±.2779	57.1364±.4072
Southwest Region:								
Umatac Salonga	53	16.9745±.0653	10.4736±.0442	61.5566±.2031	9.6698±.0415	7.0132±.0333	72.3868±.1704	56.8396±.2051
Umatac Pajom	55	16.9591±.0725	10.4891±.0438	61.6454±.1806	9.6891±.0382	6.9655±.0343	71.7545±.1674	57.0091±.1319
Umatac Madog	133	17.5695±.0704	10.7120±.0395	60.8910±.1252	9.7225±.0437	6.9827±.0277	71.7406±.1257	55.1617±.1068
Merizo	69	17.3631±.0534	10.7217±.0351	61.0942±.1902	9.6131±.0302	6.8362±.0220	70.9493±.1473	55.3261±.1508
Whole region	310	17.3135±.0375	10.6116±.0216	61.1839±.0827	9.6832±.0219	6.9522±.0153	71.6774±.0764	55.8129±.0762
Southeast Region:								
Inarajan	38	15.9895±.0787	9.7473±.0523	60.8948±.2093	9.0053±.0394	6.4421±.0309	71.4474±.1877	55.2632±.1967
Whole island	1416	16.6218±.0188	10.1877±.0112	61.2175±.0397	9.2904±.0108	6.6955±.0076	71.9520±.0375	55.7966±.0352

[1] Including the smaller local collections.

are scanty, but they are tabulated on account of their representative values; and even in the instances cited the descriptive constants are still useful for intercolonial comparisons when due allowances are made for the larger probable errors.

The tables contain the data for a great number of comparisons in detail, to limits that are set practically by the interest and patience of the student. The object of making such comparisons is to discover whether an ecological condition can be found which directly determines the size or shape of the shells in a given instance; the result is always negative, as a single illustration will indicate. Within the arbitrary bounds of the South Central Region the habitable areas are identical

TABLE 14.—*Partula radiolata, Guam. Statistical description: standard deviations of the fundamental characters.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Northeast Region:								
Tarague...........	58	0.7511±.0470	0.4244±.0266	1.8726±.1172	0.4290±.0269	0.2935±.0184	1.8714±.1171	1.7306±.1083
East Central Region:								
Barrigarda.........	22	.6167±.0627	.5533±.0562	2.2438±.2281	.4773±.0485	.4041±.0411	2.1804±.2217	1.3205±.1343
Dededo............	144	.7716±.0306	.3840±.0153	2.2427±.0891	.3788±.0150	.2797±.0111	1.9812±.0787	1.7538±.0697
Saucio............	57	.7004±.0442	.3290±.0208	2.0424±.1290	.3730±.0235	.3114±.0196	1.8203±.1150	1.7062±.1077
Whole region [1]....	228	.7598±.0240	.3971±.0125	2.2566±.0713	.4058±.0128	.3028±.0095	2.0665±.0653	1.9135±.0604
Coast Central Region:								
Aniguac...........	37	.5904±.0462	.4231±.0331	1.9813±.1553	.4274±.0335	.3239±.0254	2.1229±.1664	1.3876±.1087
Presidio, outer......	22	.5813±.0591	.3213±.0326	2.2100±.2247	.2949±.0300	.2461±.0242	1.3817±.1405	1.4438±.1468
Whole region [1]....	78	.6476±.0249	.4724±.0255	2.4185±.1306	.4148±.0224	.3456±.0187	2.1753±.1174	1.5026±.0811
South Central Region:								
Ylig, lower.........	193	.6714±.0230	.3845±.0131	1.7821±.0611	.3693±.0126	.2672±.0092	1.8529±.0635	1.3722±.0471
Ylig, upper.........	25	.7113±.0678	.2913±.0278	2.0591±.1963	.3997±.0381	.2562±.0244	1.9976±.1905	1.6030±.1529
Pago River.........	17	.6598±.0763	.4589±.0531	1.5135±.1751	.3852±.0445	.2981±.0344	1.5248±.1763	1.5362±.1777
Pago, north........	43	.8809±.0640	.4865±.0353	1.8801±.1367	.4810±.0350	.3339±.0242	1.8973±.1379	1.8813±.1368
Lonfit.............	24	.6475±.0630	.4038±.0393	1.8023±.0781	.3865±.0376	.2847±.0277	1.4085±.1371	1.4529±.1414
Ordot.............	43	.5607±.0408	.2948±.0214	1.7399±.1265	.3427±.0249	.2191±.0159	1.8047±.1312	1.4931±.1086
Macajna...........	25	.4349±.0423	.3326±.0324	1.4288±.1391	.2846±.0277	.1985±.0193	1.5473±.1506	1.5473±.1506
Fonte.............	21	.6064±.0616	.3594±.0365	1.4892±.1514	.3113±.0316	.1984±.0201	2.1359±.2171	0.9989±.1015
Whole region.....	391	.7581±.0086	.4199±.0101	1.9281±.0464	.3909±.0094	.2829±.0068	1.9665±.0474	1.6814±.0405
Apra Region:								
Cabras, east........	105	.6959±.0324	.4043±.0188	1.8928±.0881	.3754±.0174	.2940±.0136	1.5548±.0723	1.5169±.0705
Cabras, west.......	69	.7320±.0420	.4647±.0245	1.7048±.0978	.3693±.0212	.2921±.0167	1.6676±.0957	1.6900±.0970
Orote.............	128	.5189±.0218	.4898±.0206	2.1968±.0925	.4286±.0180	.3335±.0141	1.8146±.0765	2.0434±.0861
Whole region.....	302	.7916±.0217	.4559±.0215	2.0581±.0565	.4030±.0110	.3122±.0085	1.9385±.0532	1.9518±.0535
West Central Region:								
Salifan............	11	.7656±.1101	.4033±.0580	1.6818±.2418	.3814±.0547	.2328±.0334	1.3667±.1965	1.2984±.2879
Southwest Region:								
Umatac Salonga....	53	.7052±.0462	.4775±.0312	2.1927±.1436	.4470±.0293	.3592±.0235	1.8393±.1205	2.2144±.1450
Umatac Pajom.....	55	.7975±.0512	.4815±.0310	1.9855±.1277	.4202±.0270	.3777±.0242	1.8411±.1182	1.4507±.0932
Umatac Madog.....	133	1.2039±.0498	.6760±.0279	2.1410±.0885	.7478±.0309	.4732±.0196	2.1491±.0889	1.8266±.0755
Merizo............	69	.6583±.0377	.4323±.0248	2.3425±.1345	.3722±.0213	.2713±.0155	1.8141±.1041	1.8569±.1066
Whole region.....	310	.9934±.0265	.5728±.0152	2.1931±.0585	.5814±.0155	.4048±.0108	2.0251±.0540	2.0198±.0538
Southeast Region:								
Inarajan...........	38	.7191±.0556	.4865±.0376	1.9131±.1480	.3605±.0278	.2825±.0218	1.7159±.1327	1.7982±.1391
Whole island.....	1416	1.0512±.0133	.6259±.0079	2.2147±.0281	.6050±.0076	.4293±.0054	2.0916±.0265	1.9621±.0249

[1] Including the smaller local collections.

in botanical ecology, so far as observation goes. The shells of the high ground at Macajna and Fonte are short as compared with those of Ordot, which is equally high above the sea. With the descent to the Lonfit River locality, the length diminishes with a definite statistical difference; but passing eastward to the Pago River area which is still lower, the length increases, again to a certainly significant degree.

On the higher ground of the Ylig territory the shells become much larger, which is just the opposite of the first-noted relation, namely, that on the high ground of Fonte and Macajna the shells were the shortest in the whole primary region. Thus there is no consistent relation between the variations in the average length of the shells of the several associations and the differences in altitude. The same negative result is the outcome when other ecological circumstances are examined.

Taking a brief general survey of the whole material as defined by the statistics and as illustrated by figures 20 to 56, plate 11, the longest shells as indicated by the colonial average are those of Umatac Madog (fig. 27, plate 11); in the same locality the shells with the largest apertures occur. The colony with the shortest shells is that from the western part of Cabras Island, but this is followed by the series from Orote and not by the collection from the adjacent area of eastern Cabras; in fact the shortest shell of the entire series is an Orote specimen (fig. 41, plate 11). Proceeding outward from the Apra Region, the colony which comes next in the matter of shell length is that of Inarajan at the extreme southeast; in the intervening territory of the Southwest Region the shells are long and large, as we have noted.

So also in the proportionate measures the colonies vary without any discoverable relation to ecological conditions. The stoutest specimen (fig. 33, plate 11) is from Dededo, while the highest colonial average in the quality of relative width is displayed by the outer Presidio association. A slender specimen is shown in figure 30, plate 11, from Saucio.

Reverting to the character of length, the figures and the illustrations show a truly remarkable range of variation. The longest shell (fig. 27, plate 11) is 20.4 mm. long, while the shortest (fig. 41, plate 11) is only 13.6 mm. Thus the total range amounts to 6.8 mm., which is very large in comparison with the general average of this character in the whole collection, namely, 16.62 mm. When it is recalled that this measure is but one of the three general diameters of the animals, it is evident that the total bulk is subject to an extraordinary degree of variation within the species as a whole.

Turning to the regional groupings, in the nature of the case the Northeast, West Central, and Southeast Regions are each represented by only a single association. The smaller collections of the East Central and Coast Central Regions are included in the combined populations of those districts, and hence the total numbers of snails in each instance exceeds the added numbers of the groups enumerated and defined in detail. While the regional data in question are derived from very uneven geographical assemblages, they are valuable so far as they go as empirical descriptions for the larger areal divisions of the entire population. Their significance is the same as before, namely, that the environmental diversities of the several regions, such as those of altitude, nature of the soil, and the like, are not causal with reference to the structural characters of the shells. While this conclusion is readily apparent from an inspection of tables 12 to 14, it is perhaps more evident from the figures of table 15, which gives the numerical differences in mean values in the progress from one region to another; when the differences are not statistically significant they are inclosed in brackets. Taking the quality of shell length, a marked increase is noted in passing from the Northeast territory (Tarague) to the East Central Region, although the two areas are virtually identical in nature. The increase of the shells in length in passing from the Apra Region to the West Central, and further to the Southwest Region, is even more clearly indicated, although the second step involves no change in surroundings. Clearly the innate constitutional factors are responsible for the qualities displayed by the regional groups as well as for the varying colonial characters of the individual associations.

TABLE 15.—*Partula radiolata, Guam. Progressive regional comparisons.*

Region.	Mean value differences.						
	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
	Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Northeast (Tarague)	*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
	−0.6768±.0746	−0.2192±.0416	+1.0332±.1940	−0.2817±.0420	+0.2259±.0293	[−0.0919±.1897]	+0.6709±.1759
East Central							
	+0.4880±.0599	+0.2547±.0402	[−0.2247±.2104]	+0.2639±.0365	+0.1176±.0296	−0.7436±.1900	−0.2200±.1430]
Coast Central							
	[−0.0894±.0509]	−0.3593±.0388	−1.7818±.1960	−0.3068±.0344	−0.2436±.0281	−0.7658±.1791	−1.4046±.1282
South Central							
	−1.4322±.0330	−0.7623±.0228	+0.6098±.1034	−0.8027±.0205	−0.5000±.0154	+1.4023±.1008	[−0.1155±.0949]
Apra							
	+0.8184±.1587	+0.9435±.0839	+2.4669±.3512	+0.7377±.0790	+0.6977±.0478	+1.5768±.2896	+1.9642±.4142
West Central (Salifan)							
	+1.0090±.1601	+0.2025±.0848	−2.3161±.3457	+0.3832±.0804	[+0.0340±.0497]	−2.4590±.2882	−1.3235±.4143
Southwest							
	−1.3240±.0872	−0.8643±.0574	[−0.2891±.2250]	−0.6779±.0451	−0.5101±.0345	[−0.2300±.2026]	−0.5497±.2110
Southeast (Inarajan)							
	+0.9288±.0796	+0.4806±.0551	−0.4715±.2194	+0.3597±.0415	+0.2784±.0323	[−0.2901±.1993]	[+0.0245±.2048]
South Central							

The final figures of the tables (tables 12 to 14) precisely define the whole collection of *radiolata*, combined into a single inclusive series; they give an ultimate quantitative description of the species, so far as the actual material in hand is concerned. Inevitably the relative weights of the local collections are various, in correspondence with the lesser or larger numbers taken in the several representative areas; thus the fuller series from Dededo has a much greater effect upon the summary figures than the smaller collection from Barrigarda. In general, however, the irregularities balance one another in sign, and in addition a large collection at a given place usually means a greater local abundance of the species. Undoubtedly the statistical results would differ from those here recorded if a uniform representation were taken in all places, when, for example, a greater number of short shells from Inarajan would reduce the general average, while more specimens from the Umatac area would raise the figures. But the biological significance would then be different, for the summary statistics would be the general averages of the colonial averages. The actual discrepancies are not large when the second method is followed; when the 23 colonial averages of shell length are themselves averaged, the result is 16.6215 mm., as compared with the tabulated summary figure of 16.6218 mm.

No misconception can arise as to the significance of the data here presented, in view of the explicit statements above as to the material from which they are derived and which they empirically describe.

COLOR CLASSES AND THEIR COLONIAL DISTRIBUTION.

The shells of *Partula radiolata* vary considerably in coloration, although as compared with those of *P. gibba* they range within relatively narrower limits. Taking the species as a whole, no less than 6 color-classes are distinguished in the present study, of which 3 have been specifically noted in the earlier literature, while the other 3 are herein described for the first time. The position is taken that the distinctive types are not true varieties in the taxonomic sense, mainly because they are intermingled in the series from single localities and from the same regions, because their differentiation is not always carried very far, and because this differentiation is not an accompaniment of that structural diversification which was the subject of the foregoing section. If in the course of evolution the color differences should be invariably correlated with morphological distinctions, then one or another might emerge from the highly mixed assemblages of to-day to become a real variety, or even a recognizable species.

FIG. 2.—*Partula radiolata*, Guam, regional distribution of the color-classes.

FIG. 3.—*Partula radiolata*, Guam, probable interrelations of color-classes.

But whatever interpretation may be preferred, the immediate task is to describe the material in the chosen terms of color-classification, and to record the geographical distribution of the several distinguishable types. It has been stated earlier that no representative collection is exactly similar in its color composition to that from another locality. There is variation in the number of the color-types that are present, ranging from 3 to 6 where the material is ample and reliable, while the proportionate numbers of the classes vary from colony to colony. The larger significance of such facts is that, as in the case of the structural characters, we must look to the hereditary and not to the environmental factors for the causes of the phenomena as observed.

The complete census of the color-types hereinafter described (table 16) gives the actual numbers in the collections from the several localities where adult *radiolata* were found. The graphic scheme of text-figure 2 records their geographical distribution in another way. What are regarded as their probable genetic inter-relationships are shown diagrammatically in text-figure 3.

The dominant type at present is the one named **flavea** (figs. 27 to 32, plate 11). Apparently it was the most abundant in the original collection returned by Cuming to Pfeiffer, for it answers to the early description in being "pale straw-colored, rayed with darker streaks and brown lines." At the periphery the peculiar streaks of such shells are expanded so as to present the semblance of an indistinct band.

TABLE 16.—*Partula radiolata, Guam. Census of the color-classes.*

Series.	No. of adults.	**pallida.**	**flavea.**	**fulva.**	**strigata.**	**strigata-helix.**	**bicestata.**
Northeast Region:							
Tarague	62	19	36	7	....	....	....
East Central Region:							
Lolo	2	2	....	....	....	....	....
Barrigarda	23	10	12	....	....	1	....
Ukudu	4	1	3	....	....	....	....
Dededo	148	20	70	54	....	4	....
Saucio	62	22	38	....	....	....	1
Coast Central Region:							
Tumon	2	....	2	....	....	....	....
Oco	2	....	2	....	....	....	....
Timoneng	2	....	1	1	....	....	....
Dungcas	1	1	....	....	....	....	....
(Agaña, garden)	7	3	4	....	....	....	....
Agaña	3	....	....	....	....	....	3
Aniguac	41	13	28	....	....	....	....
Cemetery	3	....	3	....	....	....	....
Presidio, outer	23	5	18	....	....	....	....
Presidio, inner	1	....	1	....	....	....	....
South Central Region:							
Ylig, lower	204	60	134	....	10	....	....
Ylig, upper	28	17	11	....	....	....	....
Pago River	19	2	17	....	....	....	....
Pago, north	52	15	25	12	....	....	....
Lonfit	26	1	19	6	....	....	....
Ordot	45	3	39	3	....	....	....
Macajna	29	2	23	4	....	....	....
Fonte	22	7	15	....	....	....	....
Apra Region:							
Cabras, east	112	....	8	....	64	....	40
Cabras, west	69	....	1	....	37	20	11
Orote	130	18	39	19	44	....	10
West Central Region:							
Agat	1	1	....	....	....	....	....
Salifan	13	1	1	....	....	....	11
Southwest Region:							
Umatac Salonga	64	21	43	....	....	....	....
Umatac Pajom	62	16	46	....	....	....	....
Umatac Madog	144	50	90	....	....	4	....
Merizo	83	20	63	....	....	....	....
Southeast Region:							
Inarajan	46	12	22	12	....	....	....
Whole Island	1,535	342	814	118	155	29	77

Pilsbry has called attention to this unusual character and has given an excellent enlarged figure of the peripheral region in question (*Manual of Conchology*, vol. 20, fig. 4, plate 41). The census table shows that **flavea** is present in almost every locality, and that it is usually the dominant type where it occurs, although there are some most interesting exceptions.

Closely related to the foregoing is the form here called **pallida** on account of the general dilution of the typical colors (figs. 20 to 26, plate 11). The ground-color is very pale with only a slight tinge of yellow, and the brown streaks are fewer; the inner wall of the last whorl is also much paler in color. It is possible that certain shells referred to this class are really pale **flavea**, but if that is the case, they are nevertheless distinguishable in the phenotypic sense. The lighter tints are not the result of senescent changes, for partly-grown individuals are quite as easily separated from their **flavea** associates (compare figs. 26 and 32, plate 11). There are many instances where the attenuation of the colors leads to a virtual albinism, manifested by the inner and outer surfaces, including the whole apical region (fig. 21, plate 11). This color class is next to **flavea** in abundance throughout the island.

The third form like the second is close to the fundamental **flavea** group with which it appears to intergrade so as to make it difficult in some instances to effect a satisfactory separation of the two classes; no such difficulties are encountered in other colonies. The name employed is **fulva**, in recognition of the fox-red tinge of the ground-color, which confers a somewhat fleshy cast to the whole shell; darker streaks of the same color traverse the whorls transversely (figs. 33 to 36, plate 11). In clear contrast with **flavea**, the apex, the general outer surface, and the inner walls display the reddish coloration. Such are the **fulva** shells found in the East Central Region; those of the South Central Region are not so reddish, but are properly to be assigned to the **fulva** class, even though their colors are sometimes rather pale. Presumably **fulva** is the variety mentioned by Pfeiffer as "testa carnea, radiis cinnamomeis," but the question of correspondence is not essential.

Just as the three classes described above constitute a natural subdivision, so the three remaining types are more intimately related mutually. The most abundant of these is **strigata** (figs. 37 to 44, plate 11), in which the shell is clearly marked with brown or purplish-brown streaks alternating with lighter areas. The yellowish and light-reddish shades of **flavea** and **fulva** are never displayed. The apex is nearly or quite uniform in color and agrees with the darker strigations of the larger whorls, while the inner surface is colored like the outer. Partly-grown individuals of this class are distinctly marked, even when they are very small (figs. 43, 44, plate 11). This is certainly the form named *P. radiolata rushii* by Pilsbry in the *Manual* (loc. cit., p. 318). The description applies, and the locality given by Rush as "Port San Luis d' Apra" is the harbor on which are situated the Cabras and Orote areas, where the present material was procured. In my own opinion the form does not merit full varietal standing, but should take its place as a color-type among the others of its species. The occurrence of this form in the Lower Ylig locality is noteworthy, as that area is far removed from the Apra Region, in which **strigata** has its present headquarters; yet the Ylig specimens are unmistakable members of this color-class.

One of the most interesting types is the next, denoted **strigata-helix** (figs. 45 to 48, plate 11). The shells resemble those of **strigata** in general appearance, but the lines are finer and closer as a rule. The distinctive feature is the revolving purple or purple-brown helix along the borders of the uppermost whorls; *this is displayed by many of their embryonic young from the very outset of shell formation, and* *it continues through adolescence to maturity;* therefore it constitutes a real color-character, worthy of full recognition. Another matter of interest is the wide dispersal of such shells in places as far separated as Cabras, Umatac, and the East Central Region; while this point is reserved for future discussion, it is sufficiently striking to be emphasized here.

The sixth and last color-class is distinguished as **bicestata** (figs. 49 to 56, plate 11). The most typical shells are as light as **flavea** or even **pallida** in ground-color; revolving purplish or purplish-brown bands lie along the sutures of the upper whorls, and extend over the body-whorl with greater or lesser distinctness nearly to the lip. In the Salifan locality the deepest colored shells are found (figs. 49 to 51, plate 11), while in the Apra and the northern regions the colors are lighter, the revolving bands are browner, and the bands more frequently fade out as they extend over the last whorl (figs. 52 to 56, plate 11). There is no possibility of confusing this type with **strigata-helix**, even though the apical coloration is similar. Here too it must be noted that adolescent shells are found which display the typical markings (figs. 55, 56, plate 11), and even many of the embryonic shells also exhibit the apical helix and the revolving bands; hence there is no question of changing color during growth. Light examples of this class are undoubtedly what Pilsbry had in hand in describing "a form collected by Quadras"; in fact, the author has seen the particular shell figured by Pilsbry (*Manual*, vol. 20, fig. 2, plate 41), and it is exactly like specimens secured personally in the Agaña area, in which the bands of the last whorl are evanescent, although the markings of the spire and the general ground-color stamp the shell as a **strigata-helix**.

Such, then, are the distinguishable color-classes of *radiolata*. If we take them on the basis of their manifest qualities, their inter-relationships are capable of representation as in text-figure 3 already mentioned, which is self-explanatory. It is quite another question as to what the actual genetic relations may be, and there is nothing in the material which would justify a final statement in factorial terms. Nevertheless, it is permissible at least to suggest the factor basis. If the typical yellow factor of **flavea** were diminished in strength, or were entirely absent, **pallida** would result; if it were supplemented by the factor for reddish, **fulva** would arise. The factor for transverse streaks is universally lacking in the foregoing classes, but when it is present it is accountable for the type of coloration called **strigata**; when this is accompanied by a determiner for revolving bands, the result is the **strigata-helix** pattern. In the absence of the factor for strigation, and with the extension of the effect of the last-named factor for revolving bands, the **bicestata** type would result. The actual relations, to repeat, may be different, but for purposes of summary description the terms of factorial elements have a certain utility.

Reverting now to the phenomena of distribution, it is entirely clear from the census table (table 16) just how the colonial color-composition varies from place to place and from region to region. The lighter color-classes of **flavea** and **pallida** are almost ubiquitous, while the others occur only sporadically. The dominance of the strigated shells in the Apra territory is a striking feature. The scattering occurrence of **fulva** is another notable point. Still more interesting is the existence of **bicestata**

TABLE 17.—*Partula radiolata, Guam. Statistics of the color-classes; colonies of the Northeast, East Central, and Coast Central Regions.*

Series.	No.	Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
MEAN VALUE.								
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Taragúe:								
flavea	34	17.2029±.0665	10.6471±.0432	61.8529±.1879	9.7176±.0460	7.1176±.0343	72.9412±.1927	56.3824±.1556
pallida	18	17.2500±.0940	10.4667±.0602	60.8333±.2854	9.7222±.0579	7.0223±.0412	72.1112±.3050	56.2777±.3247
fulva	6	17.0000±.1315	10.2667±.1665	60.5000±.6929	9.4333±.1760	6.9667±.0880	73.6666±.6036	55.3333±.6242
All	58	17.1965±.0665	10.5517±.0376	61.3966±.1658	9.6896±.0380	7.0724±.0260	72.7586±.1657	56.2414±.1532
Barrigarda:								
flavea	12	16.4500±.1224	10.4167±.0892	63.2500±.4908	9.4333±.0875	6.8667±.0725	72.7500±.4505	57.3333±.2956
pallida	9	16.6833±.1353	10.5222±.1505	61.9444±.3018	9.6333±.1011	6.9889±.1019	72.1666±.4105	57.0555±.2396
strigata-helix	1	16.8500	10.1000	59.5000	9.9000	6.9000	69.5000	57.5000
All	22	16.5637±.0887	10.4455±.0795	62.5454±.3226	9.5363±.0686	6.9182±.0581	72.3636±.3135	57.2273±.1899
Dededo:								
flavea	68	16.7485±.0574	10.4500±.0318	62.4118±.1640	9.5500±.0333	6.9117±.0252	72.2647±.1563	56.9853±.1349
pallida	19	16.5974±.1068	10.2684±.0570	61.9211±.2984	9.5526±.0447	6.7421±.0383	70.5000±.1739	57.3421±.2145
fulva	53	16.0066±.0629	10.2547±.0321	63.6321±.2219	9.3113±.0289	6.8019±.0196	72.9151±.1462	58.1604±.1697
strigata-helix	4	16.8500±.1892	10.7500±.0559	64.0000±.5058	9.6500±.1295	7.2500±.0299	75.5000±1.0664	57.5000±.2384
All	144	16.4583±.0433	10.3625±.0216	62.8403±.1260	9.4653±.0213	6.8584±.0157	72.3611±.1113	57.4792±.0986
Saucio:								
flavea	37	16.3203±.0736	10.1486±.0372	61.6892±.2060	9.1757±.0397	6.7469±.0333	73.6531±.2142	55.8513±.1694
pallida	18	16.9500±.1042	10.2777±.0484	60.6112±.3388	9.2666±.0655	6.8223±.0510	73.5555±.2215	54.5556±.2827
bicestata	2	16.1000±.0715	10.4000±.0477	64.0000±.2384	9.1000±.0	7.0000±.0477	76.0000±.7154	56.5000±.0
All	57	16.5237±.0626	10.1982±.0294	61.4293±.1824	9.2017±.0333	6.7913±.0278	73.6930±.1626	55.4649±.1524
Aniguac:								
flavea	26	16.9885±.0802	10.6308±.0523	62.3461±.2533	9.7923±.0493	7.0077±.0410	71.8461±.2934	57.2308±.1818
pallida	11	16.7955±.1067	10.2637±.0752	61.1364±.3807	9.5000±.0965	6.7546±.0577	70.9546±.3508	56.5000±.2601
All	37	16.9311±.0654	10.5216±.0469	61.9865±.2197	9.7054±.0474	6.9324±.0359	71.5811±.2354	57.0135±.1538
Presidio, outer:								
flavea	17	17.1863±.0980	10.9706±.0525	63.9706±.3130	9.6882±.0508	7.1706±.0433	73.5588±.2411	56.6765±.2190
pallida	5	17.2100±.1557	10.9400±.0965	63.9000±.9069	9.8200±.0615	7.2200±.0482	73.3000±.2955	56.9000±.5259
All	22	17.1909±.0836	10.9636±.0462	63.9546±.3178	9.7182±.0424	7.1818±.0343	73.5000±.1987	56.7273±.2076
STANDARD DEVIATION.								
Taragúe:								
flavea	34	0.5751±.0470	0.3736±.0305	1.6248±.1328	0.3981±.0325	0.2965±.0242	1.6661±.1362	1.3452±.1100
pallida	18	.5916±.0664	.3786±.0425	1.7955±.2018	.3645±.0409	.2594±.0291	1.9198±.2156	2.0428±.2296
fulva	6	.4775±.0930	.6046±.1177	2.5166±.4899	.6394±.1244	.3197±.0622	2.1922±.4268	2.2669±.4414
All	58	.7511±.0470	.4244±.0266	1.8726±.1172	.4290±.0269	.2935±.0184	1.8714±.1171	1.7306±.1083
Barrigarda:								
flavea	12	.6285±.0865	.4580±.0631	2.5207±.3470	.4497±.0619	.3727±.0512	2.3139±.3185	1.5184±.2090
pallida	9	.6018±.0957	.6696±.1064	1.3426±.2134	.4497±.0715	.4532±.0720	1.8258±.2902	1.0657±.1694
strigata-helix	1	....	....	....	....	....	....	....
All	22	.6167±.0627	.5533±.0562	2.2438±.2281	.4773±.0485	.4041±.0411	2.1804±.2217	1.3205±.1343
Dededo:								
flavea	68	.7015±.0406	.3886±.0225	2.0054±.1159	.4078±.0235	.3084±.0178	1.9107±.1105	1.6493±.0954
pallida	19	.6900±.0755	.3686±.0403	1.9288±.2110	.2890±.0316	.2477±.0271	1.1239±.1229	1.3865±.1509
fulva	53	.6796±.0445	.3467±.0227	2.3952±.1569	.3118±.0204	.2114±.0138	1.5777±.1034	1.8320±.1200
strigata-helix	4	.5612±.1338	.1658±.0395	1.5000±.3576	.3840±.0916	.0886±.0211	3.1623±.7540	0.7071±.1686
All	144	.7716±.0306	.3840±.0153	2.2457±.0891	.3788±.0150	.2797±.0111	1.9812±.0787	1.7538±.0697

TABLE 17.—*Partula radiolata, Guam*—Continued.

STANDARD DEVIATION—Continued.

Series.	No.	Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Saucio:								
flavea	37	0.6637±.0520	0.3366±.0263	1.8576±.1456	0.3582±.0281	0.3001±.0235	1.9322±.1514	1.5283±.1198
pallida	18	.6557±.0737	.3047±.0342	2.1315±.2395	.4123±.0463	.3207±.0360	1.3933±.1566	1.7786±.1999
bicestata	2	.1500±.0505	.1000±.0337	0.5000±.1686	.0	.1000±.0337	1.5000±.5058	.0
All	57	.7004±.0442	.3290±.0208	2.0424±.1290	.3730±.0235	.3114±.0196	1.8203±.1150	1.7062±.1077
Aniguac:								
flavea	26	.6068±.0567	.3595±.0370	1.9154±.1791	.3730±.0348	.3099±.0290	2.2182±.2074	1.3744±.1285
pallida	11	.5246±.0754	.3699±.0532	1.8719±.2692	.4748±.0682	.2840±.0408	1.7249±.2480	1.2792±.1839
All	37	.5904±.0462	.4231±.0331	1.9813±.1553	.4274±.0335	.3239±.0254	2.1229±.1664	1.3876±.1087
Presidio, outer:								
flavea	17	.5989±.0693	.3213±.0371	1.9133±.2213	.3105±.0359	.2651±.0306	1.4741±.1705	1.3389±.1548
pallida	5	.5161±.1101	.3200±.0682	3.0066±.6413	.2039±.0435	.1600±.0341	0.9798±.2089	1.7435±.3718
All	22	.5813±.0591	.3213±.0326	2.2100±.2247	.2949±.0330	.2461±.0242	1.3817±.1405	1.4438±.1468

in widely separated localities like the Apra Region, Agaña, and Saucio, and of **strigata-helix** in equally disconnected places without intermediate representatives, even where the collections are large. The significance of such facts is obvious, and it is not necessary to repeat the arguments with regard to the relative values of hereditary and environmental circumstances; *mutatis mutandis*, what has been said concerning the variations in structural characters holds true for the qualities of coloration with equal if not with greater cogency.

STATISTICAL CHARACTERS OF THE COLOR-CLASSES.

The ultimate analysis of the *radiolata* material involves the comparative treatment of the subordinate color-groups within the several associations, on the basis of the quantitative characters of the shells. In effect, therefore, the subjects of the two preceding sections are combined and carried to their final stage of discussion. The fundamental purpose of this task is to record the facts as observed in order that they may be available for future studies of a similar nature that may some time be made, and whose results would disclose the nature and extent of such colonial changes as would have taken place in the interim. This object is accomplished by the presentation of the full data of tables 17 to 20, which comprise the statistics for the colonies of sufficient size to warrant their detailed description.

While it is unnecessary to develop the argument at length, it is obligatory to point out that here again are abundant evidences showing that there are no causal effects of the environment. In the first place, under the identical conditions of one and the same locality, two color-classes may be distinctly different in structural qualities; for example, in the case of the lower Ylig series (table 18) the **strigata** shells are collectively short and stout as compared with their lighter-colored associates. Conversely the members of a particular color-type existing in two

TABLE 18.—*Partula radiolata, Guam. Statistics of the color-classes; colonies of the South Central Region.*

MEAN VALUE.								
Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Ylig, lower:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
flavea	126	17.1310±.0389	10.2508±.0236	59.8254±.1045	9.3730±.0229	6.6429±.0167	70.6667±.1093	54.6508±.0797
pallida	58	17.2793±.0651	10.3448±.0335	59.7759±.1626	9.4517±.0311	6.6483±.0217	70.2414±.1697	54.5345±.1174
strigata	9	16.8833±.0807	10.3222±.0494	61.1666±.3351	9.3667±.0561	6.7444±.0509	71.6111±.2883	55.5000±.4239
All	193	17.1609±.0326	10.2824±.0186	59.8731±.0865	9.3964±.0179	6.6492±.0130	70.5829±.0899	54.6554±.0666
Ylig, upper:								
flavea	11	17.2864±.1590	10.4091±.0634	60.1364±.4359	9.4273±.0741	6.7000±.0490	71.8636±.4731	54.4011±.3409
pallida	14	17.1714±.1165	10.4714±.0488	61.1428±.3380	9.5286±.0757	6.8000±.0467	71.2143±.3079	55.4286±.2500
All	25	17.2220±.0959	10.4440±.0393	60.7000±.2777	9.4840±.0539	6.7560±.0345	71.1400±.2695	54.9800±.2162
Pago River:								
flavea	15	17.0500±.1162	10.1800±.0842	59.5000±.2776	9.3400±.0710	6.7133±.0546	71.7666±.2806	54.6333±.2452
pallida	2	16.5500±.1431	10.0000±.0477	60.0000±.2385	9.4000±.0477	6.8000±.0477	72.0000±.2385	50.000 ±.2385
All	17	16.9912±.1079	10.1588±.0751	59.5888±.2476	9.3470±.0630	6.7235±.0487	71.7941±.2494	54.9117±.2512
Pago North:								
flavea	21	16.7786±.1210	10.3095±.0706	61.4524±.3133	9.4238±.0718	6.7381±.0502	71.5952±.2525	56.1667±.2885
pallida	12	16.5500±.1893	10.1167±.0960	61.1667±.3009	9.2667±.0868	6.6833±.0645	71.8333±.4520	56.0000±.3770
fulva	10	16.7300±.1837	10.4000±.0879	62.0000±.3338	9.4800±.1017	6.7800±.0666	71.2000±.3446	56.7000±.3276
All	43	16.7035±.0906	10.2767±.0500	61.5000±.1934	9.3930±.0495	6.7325±.0343	71.5697±.1951	56.2442±.1935
Lonfit:								
flavea	18	16.5000±.1081	9.8778±.0686	59.8889±.3141	9.2333±.0686	6.5555±.0471	70.6111±.2241	56.0000±.2499
pallida	1	17.1500	10.1000	58.5000	9.3000	6.7000	70.5000	54.5000
fulva	5	16.4900±.1557	10.0220±.0903	60.5000±.2698	9.1800±.0615	6.6200±.0615	71.9000±.3076	55.5000±.3304
All	24	16.5250±.0891	9.9166±.0556	59.9583±.1104	9.2250±.0532	6.5750±.0392	70.8750±.1939	55.8333±.2000
Ordot:								
flavea	37	16.9554±.0564	10.3865±.0265	61.2838±.1913	9.4135±.0359	6.8892±.0224	73.0135±.2039	55.5540±.1689
pallida	3	16.8500±.1908	10.1000±.0636	59.5000±.5507	9.3667±.1323	6.8333±.0367	72.5000±.5507	55.5000±.3179
fulva	3	16.6500±.3855	10.3667±.2567	62.5000±.0	9.5667±.1943	6.8333±.1600	71.5000±.3179	57.1667±.1836
All	43	16.9267±.0577	10.3651±.0303	61.2442±.1789	9.4209±.0352	6.8814±.0225	72.8721±.1856	55.6628±.1536
Macajna:								
flavea	22	16.1818±.0535	10.1000±.0416	62.3636±.2092	9.3453±.0323	6.6909±.0267	71.6364±.2180	57.5000±.2168
pallida	1	17.1500	10.3000	60.5000	9.9000	6.9000	69.5000	58.5000
fulva	2	15.6500±.1431	9.7000±.2568	61.5000±.0	8.8000±.0477	6.4000±.0477	72.5000±.5841	56.000±.7154
All	25	16.1780±.0599	10.0760±.0458	62.2200±.1967	9.3240±.0392	6.6760±.0273	71.5800±.2130	57.4200±.2130
Fonte:								
flavea	14	16.0072±.0998	9.6286±.0662	60.2857±.2473	8.9571±.0499	6.3714±.0292	70.9286±.4400	56.0000±.1770
pallida	7	16.3500±.1635	9.7857±.0811	60.5000±.4509	9.0428±.0933	6.5571±.0525	72.3571±.1629	55.6428±.2523
All	21	16.1214±.0872	9.6810±.0517	60.3572±.2141	8.9857±.0447	6.4333±.0285	71.4048±.3071	55.8809±.1436

TABLE 18.—*Partula radiolata, Guam*—Continued.

STANDARD DEVIATION.

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Ylig, lower:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
flavea	126	0.6478±.0275	0.3925±.0167	1.7404±.0739	0.3818±.0162	0.2782±.0118	1.8203±.0773	1.3277±.0563
pallida	58	.7351±.0460	.3788±.0237	1.8364±.1150	.3509±.0220	.2451±.0153	1.9169±.1200	1.3257±.0830
strigata	9	.3590±.0570	.2199±.0349	1.4907±.2369	.2494±.0396	.2266±.0360	1.2823±.2038	1.8856±.2997
All	193	.6714±.0230	.3845±.0131	1.7821±.0611	.3693±.0126	.2672±.0092	1.8529±.0635	1.3721±.0471
Ylig, upper:								
flavea	11	.7819±.1124	.3118±.0448	2.1436±.3082	.3645±.0524	.2412±.0341	2.3266±.3345	1.6763±.2410
pallida	14	.6461±.0824	.2710±.0345	1.8749±.2390	.4199±.0535	.2591±.0330	1.7079±.2177	1.3869±.1768
All	25	.7113±.0678	.2913±.0278	2.0591±.1963	.3997±.0381	.2562±.0244	1.9976±.1905	1.6030±.1529
Pago River:								
flavea	15	.6673±.0821	.4833±.0595	1.5913±.1959	.4079±.0502	.3138±.0386	1.6111±.1984	1.4079±.1734
pallida	2	.3000±.1012	.1000±.0337	0.5000±.1686	.1000±.0337	.1000±.0337	0.5000±.1686	0.5000±.1686
All	17	.6598±.0763	.4589±.0531	1.5135±.1751	.3852±.0445	.2981±.0354	1.5248±.1763	1.5362±.1777
Pago North:								
flavea	21	.8224±.0855	.4799±.0499	2.1285±.2215	.4878±.0508	.3415±.0355	1.7156±.1785	1.9599±.2040
pallida	12	.9721±.1338	.4930±.0679	1.5456±.2127	.4460±.0614	.3312±.0456	2.3214±.3196	1.9365±.2666
fulva	10	.8612±.1299	.4123±.0621	1.5652±.2360	.4771±.0719	.3124±.0471	1.6155±.2436	1.5362±.2316
All	43	.8809±.0640	.4865±.0353	1.8801±.1367	.4810±.0350	.3339±.0242	1.8973±.1379	1.8813±.1368
Lonfit:								
flavea	18	.6801±.0764	.4315±.0485	1.9759±.2221	.4320±.0486	.2967±.0333	1.4098±.1584	1.5723±.1767
pallida	1	....	....	....	....	....	....	....
fulva	5	.5161±.1101	.2293±.0638	0.8944±.1908	.2039±.0435	.2039±.0435	1.0198±.2175	1.0954±.2336
All	24	.6475±.0630	.4038±.0393	1.8023±.0781	.3865±.0376	.2847±.0277	1.4085±.1371	1.4529±.1414
Ordot:								
flavea	37	.5088±.0399	.2395±.0187	1.7263±.1352	.3239±.0254	.2024±.0158	1.8398±.1442	1.5236±.1194
pallida	3	.4899±.1349	.1633±.0450	1.4142±.3894	.3399±.0935	.0942±.0259	1.4142±.3894	0.8165±.2248
fulva	3	.9899±.2726	.6592±.1815	.0	.4989±.1374	.4109±.1131	0.8165±.2248	0.4714±.1298
All	43	.5607±.0408	.2948±.0214	1.7399±.1265	.3427±.0249	.2191±.0159	1.8047±.1312	1.4931±.1086
Macajna:								
flavea	22	.3722±.0378	.2892±.0294	1.4552±.1479	.2251±.0228	.1856±.0189	1.5164±.1541	1.5075±.1533
pallida	1	....	....	....	....	....	....	....
fulva	2	.3000±.1012	.5385±.1816	.0	.1000±.0337	.1000±.0337	1.2247±.4130	1.5000±.5058
All	25	.4349±.0423	.3326±.0324	1.4288±.1391	.2846±.0277	.1985±.0193	1.5473±.1506	1.5473±.1506
Donte:								
flavea	14	.5538±.0705	.3673±.0468	1.3721±.1748	.2770±.0353	.1622±.0206	2.4411±.3118	0.9819±.1251
pallida	7	.6414±.1156	.3182±.0573	1.6903±.3188	.3659±.0660	.2060±.0371	0.6389±.1152	0.9897±.1784
All	21	.6064±.0616	.3594±.0365	1.4892±.1514	.3113±.0316	.1984±.0201	2.1359±.2171	0.9989±.1015

TABLE 19.—*Partula radiolata, Guam. Statistics of the color-classes; colonies of the Apra and West Central Regions.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
MEAN VALUE.								
Cabras east:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
flavea	7	15.5643±.1671	9.3572±.1114	59.7857±.2258	8.4429±.0972	6.0715±.0837	71.9286±.3568	53.9286±.1857
strigata	60	15.6150±.0602	9.4267±.0398	60.2833±.1763	8.5166±.0360	6.2434±.0279	73.1166±.1321	54.3667±.1390
bicestata	38	15.7130±.0772	9.5105±.0309	60.4474±.1959	8.4947±.0331	6.2105±.0249	72.8421±.1707	63.8684±.1576
All	105	15.6472±.0458	9.4524±.0266	60.3095±.1246	8.5038±.0247	6.2200±.0193	72.9381±.1023	54.1572±.0998
Cabras, west:								
flavea	1	15.6500	9.3000	58.5000	8.1000	5.9000	72.5000	51.5000
strigata	37	15.3824±.0803	9.4838±.0524	61.5270±.1832	8.5702±.0439	6.3000±.0389	73.0135±.2007	55.4460±.1524
strigata-helix	20	15.0350±.1103	9.2700±.0676	61.6500±.2200	8.4700±.0524	6.2100±.0277	73.1000±.2356	54.9500±.2210
bicestata	11	15.8682±.0826	9.6091±.0782	60.5000±.3780	8.5545±.0551	6.3000±.0388	73.6818±.2575	53.9546±.3716
All	69	15.3645±.0594	9.4391±.0347	61.3551±.1384	8.5319±.0300	6.2681±.0237	73.1377±.1354	55.3841±.1372
Orote:								
flavea	38	15.1369±.0874	9.3895±.0473	61.9737±.2269	8.5789±.0442	6.1368±.0328	71.3947±.1480	56.7368±.1747
pallida	18	14.9500±.0927	9.1889±.0553	61.1667±.3179	8.3778±.0499	6.0778±.0461	72.6666±.2866	45.9444±.2661
fulva	19	15.4447±.1138	9.6263±.0753	62.2368±.3785	8.6894±.0554	6.1684±.0429	71.9736±.1968	56.3421±.3264
strigata	43	15.7546±.0957	9.6349±.0561	61.9186±.2176	9.7093±.0500	6.2395±.0398	71.7690±.2234	55.0349±.2189
bicestata	10	15.8600±.1906	9.5400±.0630	60.1000±.3594	8.7800±.0712	6.3000±.0572	71.7000±.4244	55.4000±.1493
All	128	15.4203±.0309	9.4806±.0292	61.4531±.1309	8.6265±.0255	6.1953±.0199	71.8125±.1082	55.8906±.1218
Salifan:								
flavea	1	15.6500	10.3000	65.5000	8.9000	6.7000	74.5000	57.5000
pallida	1	16.2500	10.5000	64.5000	9.1000	6.9000	75.5000	55.5000
bicestata	9	16.3833±.1829	10.4111±.0997	63.1667±.3671	9.3666±.0874	6.9444±.0552	73.9445±.3244	57.2778±.2981
All	11	16.3045±.1557	10.4091±.0820	63.5000±.3420	9.3000±.0774	6.9182±.0473	74.1364±.2779	57.1364±.2640
STANDARD DEVIATION.								
Cabras, east:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
flavea	7	0.6556±.1181	0.4371±.0788	0.8857±.1596	0.3812±.0687	0.3283±.0592	1.3997±.2523	0.7285±.1313
strigata	60	.6918±.0425	.4575±.0281	2.0253±.1246	.4136±.0254	.3206±.0197	1.5176±.0934	1.5965±.0983
bicestata	38	.7058±.0546	.2826±.0218	1.7910±.1385	.3026±.0234	.2280±.0176	1.5606±.1207	1.4403±.1114
All	105	.6959±.0324	.4043±.0188	1.8928±.0881	.3754±.0174	.2940±.0136	1.5548±.0723	1.5169±.0705
Cabras, west:								
flavea	1	....	....	....	....	....	....	....
strigata	37	.7241±.0568	.4728±.0370	1.6519±.1295	.3965±.0310	.3511±.0275	1.8102±.1419	1.3744±.1077
strigata-helix	20	.7316±.0780	.4484±.0478	1.4586±.1555	.3479±.0370	.1841±.0196	1.5620±.1666	1.4654±.1563
bicestata	11	.4063±.0584	.3848±.0553	1.8586±.2673	.2709±.0389	.1907±.0274	1.2662±.1821	1.8273±.2627
All	69	.7320±.0420	.4647±.0245	1.7048±.0978	.3693±.0212	.2912±.0167	1.6676±.0957	1.6900±.0970
Orote:								
flavea	38	.7994±.0618	.4321±.0334	2.0741±.1604	.4040±.0312	.3003±.0232	1.3532±.1046	1.5966±.1235
pallida	18	.5831±.0655	.3478±.0391	2.0000±.2248	.3137±.0353	.2898±.0326	1.8029±.2026	1.6741±.1881
fulva	19	.7354±.0804	.4865±.0532	2.4461±.2676	.3582±.0392	.2773±.0303	1.2719±.1391	2.1092±.2308
strigata	43	.9306±.0677	.5451±.0396	2.1156±.1538	.4860±.0353	.3871=.0281	2.1722±.1579	2.1279±.1548
bicestata	10	.8935±.1348	.2954±.0445	1.6852±.2541	.3340±.0503	.2683±.0404	1.9899±.3001	0.7000±.1056
All	128	.5189±.0218	.4898±.0206	2.1968±.2541	.4286±.0180	.3335±.0141	1.8146±.0765	2.0434±.0861
Salifan:								
flavea	1	....	....	....	....	....	....	....
pallida	1	....	....	....	....	....	....	....
bicestata	9	.8137±.1293	.4433±.0705	1.6328±.2596	.3387±.0618	.2454±.0390	1.4229±.2294	1.3260±.2108
All	11	.7656±.1101	.4033±.0580	1.6818±.2418	.3814±.0547	.2328±.0334	1.3667±.1965	1.2984±.1867

TABLE 20.—*Partula radiolata, Guam. Statistics of the color-classes; colonies of the Southwest and Southeast Regions.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
MEAN VALUE.								
Umatac Salonga:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
flavea	35	16.9186±.0830	10.4829±.0554	61.7857±.2550	9.6200±.0482	7.0429±.0413	73.0143±.1895	56.8143±.2589
pallida	18	17.0833±.1023	10.4556±.0731	61.1111±.3229	9.7666±.0757	6.9556±.0549	71.1667±.2428	56.8889±.3311
All	53	16.9745±.0653	10.4736±.0442	61.5561±.2031	9.6698±.0415	7.0132±.0333	72.3868±.1704	56.8396±.2051
Umatac Pajom:								
flavea	39	17.0346±.0860	10.5000±.0549	61.4231±.2312	9.7410±.0464	6.9923±.0437	71.6282±.1989	57.0897±.1707
pallida	16	16.7750±.1296	10.4625±.0687	62.3875±.2363	9.5625±.0616	6.9000±.0491	72.0625±.3038	56.8125±.1760
All	55	16.9591±.0725	10.4891±.0438	61.6454±.1806	9.6891±.0382	6.9655±.0343	71.7545±.1674	57.0091±.1319
Umatac Madog:								
flavea	86	17.6628±.0898	10.7348±.0527	60.6395±.1464	9.7791±.0568	7.0000±.0367	71.5348±.1387	55.1395±.1278
pallida	43	17.3733±.1187	10.6642±.0611	61.3139±.2790	9.5967±.0703	6.9233±.0433	72.0116±.2571	55.1512±.2043
strigata-helix	4	17.6750±.2413	10.9500±.0292	61.7500±.6476	9.8500±.1536	7.2500±.0559	73.2500±.6476	55.7500±.4381
All	133	17.5695±.0704	10.7120±.0395	60.8910±.1252	9.7225±.0437	6.9827±.0277	71.7406±.1257	55.1617±.1068
Merizo:								
flavea	54	17.3500±.0580	10.7259±.0382	61.1852±.2176	9.6000±.0351	6.8259±.0255	70.9629±.1654	55.2963±.1813
pallida	15	17.4100±.1276	10.7067±.0842	60.7666±.3841	9.6600±.0571	6.8734±.0419	70.9000±.3230	55.4334±.2333
All	69	17.3631±.0534	10.7217±.0351	61.0942±.1902	9.6131±.0302	6.8362±.0220	70.9493±.1473	55.3261±.1508
Inarajan:								
flavea	21	16.0377±.1265	9.7476±.0786	60.7857±.2949	9.0333±.0625	6.4417±.0464	71.2619±.2796	56.2619±.2905
pallida	6	16.0000±.1747	9.6666±.1026	60.1667±.3434	9.0000±.0693	6.3667±.0687	71.0000±.3812	56.3333±.4878
fulva	11	15.8955±.0772	9.7909±.0890	61.5000±.3780	8.9546±.0523	6.4818±.0440	72.0454±.2653	56.2276±.2888
All	38	15.9895±.0787	9.7473±.0532	60.8948±.2093	9.0053±.0394	6.4421±.0309	71.4474±.1877	56.2632±.1967
STANDARD DEVIATION.								
Umatac Salonga:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
flavea	35	0.7281±.0587	0.4861±.0392	2.2367±.1803	0.4228±.0341	0.3628±.0292	1.6626±.1340	2.2709±.1831
pallida	18	.6438±.0723	.4597±.0517	2.0314±.2283	.4762±.0535	.3452±.0388	1.5275±.1717	2.0829±.2341
All	53	.7052±.0462	.4775±.0312	2.1927±.1436	.4470±.0293	.3592±.0235	1.8393±.1205	2.2144±.1450
Umatac Pajom:								
flavea	39	.7969±.0608	.5084±.0388	2.1409±.1635	.4301±.0328	.4047±.0309	1.8422±.1406	1.5806±.1207
pallida	16	.7685±.0916	.4075±.0486	1.4017±.1671	.3655±.0435	.2915±.0347	1.8017±.2148	1.0439±.1244
All	55	.7975±.0512	.4815±.0310	1.9855±.1277	.4202±.0270	.3777±.0242	1.8411±.1182	1.4507±.0932
Umatac Madog:								
flavea	86	1.2343±.0635	.7251±.0372	2.0125±.1035	.7807±.0401	.5009±.0259	1.9074±.0981	1.7581±.0903
pallida	43	1.1539±.0839	.5919±.0432	2.7131±.1973	.6839±.0497	.4209±.0306	2.4999±.1818	1.9869±.1444
strigata-helix	4	.7155±.1706	.0866±.0206	1.9203±.4579	.4555±.1086	.1658±.0395	1.9203±.4579	1.2990±.3098
All	113	1.2039±.0498	.6760±.0279	2.1410±.0885	.7478±.0309	.4732±.0196	2.1491±.0889	1.8266±.0755
Merizo:								
flavea	54	.6324±.0410	.4169±.0270	2.3713±.1538	.3825±.0248	.2783±.0180	1.8024±.1169	1.9756±.1282
pallida	15	.7328±.0902	.4837±.0595	2.2054±.2716	.3282±.0404	.2409±.0296	1.8547±.2284	1.3399±.1649
All	69	.6583±.0377	.4323±.0248	2.3425±.1345	.3722±.0213	.2713±.0155	1.8141±.1041	1.8569±.1066
Inarajan:								
flavea	21	.8593±.0894	.5342±.0555	2.0034±.2085	.4246±.0442	.3154±.0328	1.8999±.1977	1.9737±.2054
pallida	6	.6344±.1235	.3727±.0725	1.2473±.2428	.2516±.0490	.2494±.0486	1.3844±.2695	1.7717±.3449
fulva	11	.3799±.0546	.4379±.0629	1.8586±.2673	.2571±.0370	.2167±.0311	1.3048±.1876	1.4200±.2042
All	38	.7191±.0556	.4865±.0376	1.9131±.1480	.3605±.0278	.2825±.0218	1.7159±.1327	1.7982±.1391

different places may be identical in morphological respects; thus the **bicestata** classes prove to be virtually the same in the length and in the proportions of their shells, in western Cabras and Orote, which localities exhibit minor differences in botanical features and a more marked difference in the matter of altitude

While it is interesting to speculate as to the antecedent episodes in the history of *radiolata* leading to the present situation, it must be admitted that the facts of record do not throw much light upon this history. One fundamental point is firmly established, namely, that the six color-classes are unquestionably members of one and the same species, because they agree in the general diagnostic features and also because they interbreed mutually, as the evidences to be presented in the next section will demonstrate. It is permissible to regard some at least of the several color-types as mutants, showing various degrees of distinctness, but the material itself gives no answer to the question as to which was the original form and which are the products by independent or derived mutation. It is true that the **flavea** class is the most abundant at the present time, but it is conceivable that another class was really ancestral to **flavea** and that this parent class has diminished in numbers while its product has gained ascendancy. To make the problem more specific, we may consider the case of **bicestata**, which now occurs in the widely separated localities of Saucio, Agaña, the Apra Region, and on Mount Salifan.

The hypothesis is tenable that this form was at one time abundant and widespread and that the genetic factors responsible for its manifestation have dropped out, save in a few associations. It is also conceivable that the mutation by which it may be assumed to have arisen at one place has occurred in an identical manner and independently in another area. A third possibility is that the type arose at a single center, from which it subsequently spread to other territories; such an episode might well have preceded the first-mentioned process of local decimation and extinction, to which it is by no means an exclusive alternative. If the **bicestata** pattern arose by mutation at a single place, it must have been displayed at the outset by only a few snails whose structural characters would unquestionably be different from the general colonial averages unless the parental individual were itself average in all respects, which never seems to be the case. Because a certain amount of assortative mating takes place owing to the disinclination of the animals to wander far from their nurse-plants, the number of individuals with the distinctive pattern and similar measures would increase. As time passed, the larger numbers of the new kind would migrate over wider areas and necessarily interbreed with differently colored and differently formed members of the species; inevitably the original structural distinctness of the new type would become less marked as the intermixture continued, while the manifestation of the peculiar pattern would depend upon the requisite combination of the genetic factors responsible for it. Possibly there are indications of such a history in the larger size of the **bicestata** shells in the Cabras, Orote, and Salifan areas, although the differences between such individuals and their associates are not always statistically significant.

However, the statistical differences between and among the several color-classes of *radiolata*, as they stand to-day, are not competent to solve the problems outlined in this section; perhaps the solution can be obtained only by a repeated survey after the lapse of some years.

EMBRYONIC MATERIAL.

According to the orthodox mode of the genus, *radiolata* is ovoviviparous. Full growth is attained and the flaring lip of the shell is well formed before reproductive ability is manifested. The capsules in which the fertilized eggs are inclosed are oval, from 3.5 to 4 mm. in length; when several are present in the brood-pouch at one time, they are so crowded as to become somewhat cask-shaped, with flat contact-surfaces. The walls of these capsules are never impregnated with calcareous material, as in the majority of the Society Island species. The embryonic snail gains a shell approximately 3.5 mm. in length before it emerges to lead its independent life.

TABLE 21.—*Partula radiolata, Guam. Statistics of fecundity.*

Locality.	Date (1920).	Records	Gravid.		Embryonic contents.			Average for gravid.			Average for all.
			No.	Per cent.	Eggs.	Young.	Total.	Eggs.	Young.	Total contents.	
Tarague	Aug. 15	62	56	90.32	83	76	159	1.48	1.36	2.84	2.56
Lolo	July 7	2	2	[100]	5	4	9	2.50	2.00	4.50	4.50
Barrigarda	July 19	23	20	86.95	37	20	57	1.85	1.00	2.85	2.48
Ukudu	July 2	4	3	75.00	6	6	12	2.00	2.00	4.00	3.00
Dededo	July 12	148	123	83.11	277	143	420	2.25	1.16	3.41	2.84
Saucio	July 3	62	55	88.71	130	78	208	2.36	1.42	3.78	3.35
Tumon to Agaña	Varia	17	13	76.47	32	15	47	2.46	1.15	3.61	2.76
Aniguac	Aug. 13	37	32	86.48	88	49	137	2.75	1.53	4.28	3.70
Cemetery	Aug. 8	3	3	[100]	9	6	15	3.00	2.00	5.00	5.00
Presidio, outer	Aug. 15, 16, 25.	23	20	86.95	64	36	100	3.20	1.80	5.00	4.50
Ylig, lower	July 23	204	183	89.70	551	282	833	3.01	1.54	4.55	4.06
Ylig, upper	July 23	28	26	92.86	79	38	117	3.04	1.46	4.50	4.18
Pago River	July 2	19	14	73.67	40	12	52	2.85	0.85	3.71	2.74
Pago, north	July 12	51	46	90.19	134	59	193	2.91	1.28	4.20	3.78
Lonfit	June 30	25	20	80.00	48	26	74	2.40	1.30	3.70	2.96
Ordot	June 29; Aug. 18	45	35	77.77	76	34	110	2.17	0.97	3.14	2.44
Macajna	July 18; Aug. 14	29	28	96.55	89	60	149	3.18	2.14	5.32	5.14
Fonte	July 6; July 10	21	20	95.84	40	25	65	2.00	1.25	3.25	3.09
Cabras, east	Aug. 12	109	94	86.24	246	125	371	2.62	1.33	3.95	3.40
Cabras, west	Aug. 9	69	53	76.81	172	91	263	3.24	1.72	4.96	3.81
Orote	July 10	130	121	93.07	268	179	447	2.21	1.48	3.69	3.44
Agat	Aug. 22	1	1	[100]	2	1	3	2.00	1.00	3.00	3.00
Salifan	Aug. 22	13	11	84.61	30	18	48	2.73	1.63	4.36	3.69
Umatac Salonga	July 15	64	56	87.50	187	91	278	3.34	0.62	3.96	4.34
Umatac Pajom	July 14	62	54	87.09	166	93	259	3.07	1.72	4.80	4.18
Umatac Madog	July 14, 15	144	121	84.03	372	201	573	3.07	1.66	4.73	3.98
Merizo	July 16	83	71	85.54	221	104	325	3.11	1.46	4.57	3.92
Inarajan	Aug. 22	46	32	69.56	50	37	87	1.56	1.16	2.72	1.89
Summary		1,524	1,313	86.15	3,502	1,909	5,411	2.67	1.45	4.12	3.55

The statistics of fecundity are given *in extenso* in table 21. As only a few adults were unavailable, the total number of records, 1,524, is satisfactorily high and fully representative; many of the individual associations are scanty, it is true, but their data are given in order that all observations shall be recorded. The gravid adults amounted to 86 per cent of all, and they yielded 3,502 eggs and 1,909 young snails, or a total of 5,411; thus the average embryonic contents of the bearing animals were 4.12, while the figures are 3.55 for the entire series. The latter datum is an index of the reproductive rate of the whole species during the period of collection and observation.

In other species, where the embryonic capsule is provided with calcareous substance, this material is withdrawn as the young snail forms its shell, thus leaving the capsular wall transparent; hence there is a relatively definite transition from the "egg" to the "young" period. In the case of *radiolata* no such guidance is afforded for the classification of the brood-pouch material into the two age-classes; while this classification is therefore arbitrary in a sense, it is made on the basis of long experience with thousands of young specimens in other species, and the determinations are substantially accurate.

TABLE 22.—*Partula radiolata, Guam. Aberrations in the order of embryonic contents.*

Locality.	Number of instances.	Embryonic contents.
Dededo	1	e Y e e
	1	Y e Y e e
	1	Y e Y e e e e
Ylig, lower	1	e Y e e e e
Macajna	1	e Y e
Fonte	1	e Y e
Cabras, east	1	e Y e e
	1	e Y e e e e
Cabras, west	1	Y e Y e e e
	1	e Y e e e e e
Orote	1	e Y e
	1	e Y e e
	1	Y e Y e e e
Umatac Salonga	1	Y e Y Y e e e e e
Umatac Madog	2	e Y e e
	1	e Y e e e
	2	e Y e e e e
	1	Y e Y e e e

Before proceeding to the circumstantial discussion of the returns, a minor matter of some interest may be mentioned. This is the observation that occasionally certain of the capsules within the brood-pouch or uterus contain no embryos; either an egg is present which is not fertilized, or a capsule is fully formed without receiving a zygote. In all, there are 23 such instances among the 1,313 gravid snails. Doubtless there were others which escaped notice, because it is only when young snail embryos are also present in a position of later formation that the so-called "anachronisms" are evident. The term "anachronism" is not properly applicable unless newly formed capsules are actually pushed past older ones to a place in the series nearer to the birth-aperture, as the writer supposed was generally the case. A few true anachronisms have been observed in Tahitian species and in *P. gibba* of the Mariana Islands, but in the case of *radiolata* there are no germs at all within the capsules in question or else an unfertilized egg is present. The exceptional cases are recorded in table 22, in which the item nearest to the birth-aperture is given first and the others follow in the order of their formation.

The number of embryos of all ages that are present in the brood-pouch ranges from none to 10; the full data are given in table 23 and require no comment.

TABLE 23.—*Partula radiolata, Guam. Recorded adults and their embryonic contents.*

	Number of young.					Totals.	
	0	1	2	3	4		
Number of eggs:							
0	211	28	9	....	....	248	
1	64	62	55	10	....	191	
2	71	115	176	25	2	389	
3	74	88	158	52	1	373	
4	30	49	109	28	7	223	
5	12	20	30	17	4	83	3502 eggs
6	5	3	4	3	....	15	
7	....	1	....	....	....	1	
8	....	....	....	....	....	...	
9	....	....	....	....	....	...	
10	1	....	....	....	....	1	
Totals	468	366	541	135	14	1524 records	
		1909 young					

Summary.	Embryonic contents.										
	0	1	2	3	4	5	6	7	8	9	10
Number of adults—1,524	211	92	142	244	304	244	188	62	29	7	1

A question of much interest is whether there is a well-defined breeding season which alternates with an interval when multiplication is suspended. In the monograph on the Tahitian species the reasons were given for the belief that the several valley colonies of such a species as *P. otaheitana* behave independently; specifically it was found that during a particular month the members of one association contained many eggs and young, while a colony in even a near-by valley would be almost barren, or at least would display a very low rate of productivity, and hence it seemed that each community possessed its own reproductive cycle without any discernible relation to seasonal changes. In *radiolata*, however, the contrary is the case, for the facts show that with the onset of hotter weather and of the heavier rains, the adult animals begin to produce a new generation of offspring.

While the ultimate proof of this assertion would require the actual collection and dissection of representative series throughout a full annual period, yet the data of table 21 provide a clear demonstration of the point, despite the fact that the material was collected during the 2 months' interval from June 28 to August 28. If production diminished or ceased during the months of lower temperature and lesser rainfall, to be resumed with the vernal intensification of these influences, then the number of eggs and young would sensibly increase with the passage of time thereafter. The period of field-work was divided into 8 time-classes of 7 days each, beginning with the arbitrary date of June 29. With the time-elements thus fixed, correlations were worked out between these elements and the numbers of gravid individuals in the several series, and also between the time-elements and the numbers of eggs and young in the parental brood-pouches. Twenty-one local series were sufficiently large to be used; the others were discarded because they were too scanty or, as in the case of the Tarague and Inarajan collections, because too long an interval elapsed between the actual collection of the animals and the time of their preservation, during which many of the advanced embryonic young escaped, thus invalidating the returns for the present purpose.

Employing the standard methods for the determination of the coefficients of correlation, the results are as follows:

Correlation between lapse of time and per cent gravid:	$+0.1696 \pm 0.0$
Correlation between lapse of time and number of eggs:	$+0.3976 \pm 0.1239$
Correlation between lapse of time and total embryonic contents:	$+0.5279 \pm 0.1062$

The first coefficient shows that there is only a slight positive increase in the number of bearing adults, which means that reproductive activity had been generally resumed somewhat earlier than the arbitrary date of June 29, when field-work was begun. The second figure proves that the production of eggs continues and increases slightly with the progress of the weeks. The third figure, taken in connection with the second, signifies that the young snails increased greatly in numbers during the period of collection and observation more rapidly than the eggs. Therefore the onset of the fertile period must have been somewhat earlier than June 29, which is corroborative of the point established by the first correlation. Referring back to the discussion of the climatic factors (Chapter I), we are justified in stating that with the month of May the older animals of this species resume reproductive activity and the full-grown virgin individuals begin their fertile life, with general unanimity throughout the island; doubtless it is the increase of moisture especially that is the major factor of their reactions.

The final subjects for which the embryonic materials are valuable are the phenomena of heredity and the question as to the genetic inter-relationships of the distinguishable color-classes. The embryonic snails are well advanced before their birth, and various characters of the shells are well expressed. On one point there is no uncertainty—the offspring are dextral without a single exception, like all of their parents and all of the adolescent individuals; there is no sporadic production of young with the opposite coil, as in *P. nodosa* and certain varieties of *P. otaheitana* of Tahiti.

A large amount of material is available for the study of the heredity of the color characters, inasmuch as the colors of all of the young snails were noted when they were dissected out of their respective parents. It is well to state at the outset, however, that the data are more valuable in a qualitative connection than in a quantitative respect, owing to certain inherent difficulties. Sometimes the young individual was clearly recognizable as a member of the same color-class as its parent, while in another case it might be assignable to a contrasted group with equal certainty; thus the fact is established that the color-types do not breed absolutely true and that they are mutually related in a real genetic sense. This is the qualitative result. When it is a question of the inter-relationships of very distinct types such as **flavea** and **strigata**, the features of contrast appear early and the figures are undoubtedly accurate for the two kinds of young taken from the parents of the one or the other class; in such cases the quantitative data also are of real value. But when **pallida** and **flavea** are under consideration, inevitable errors of observation arise, because the young shell is thin and pale in color as compared with that of an adult; hence it is not always possible to determine whether such an individual would continue light in color to become a **pallida** adult, or whether its tints would intensify with growth so as to make it an adult **flavea**. These considerations are to be kept in mind throughout the following discussion of illustrative cases, for which the specific data are given in table 24.

TABLE 24.—*Partula radiolata, Guam. Statistics of heredity of color-characters in representative colonies.*

Colony.	Gravid adults.		Young.						
	Color-class.	No.	pallida.	flavea.	fulva.	strigata.	strigata-helix.	bicestata.	Total.
Tarague..........	pallida	19	19	11	....	....	....	....	30
	flavea	30	17	19	....	....	....	....	36
	fulva	7	1	6	3	....	....	....	10
	Total	56	37	36	3	....	....	....	76
Cabras, east......	flavea	7	....	12	....	....	....	....	12
	strigata	54	....	2	....	60	....	2	64
	bicestata	33	....	1	....	2	....	46	49
	Total	94	....	15	....	62	....	48	125
Cabras, west.....	flavea	1	....	3	....	....	....	....	3
	strigata	28	....	....	....	45	....	1	46
	strigata-helix	14	....	....	....	4	11	6	21
	bicestata	10	....	....	....	....	....	21	21
	Total	53	....	3	....	49	11	28	91
Orote............	pallida	18	7	13	....	....	....	....	20
	flavea	33	4	39	3	....	....	....	46
	fulva	18	3	29	....	....	....	....	32
	strigata	43	....	7	7	51	....	....	65
	bicestata	9	1	1	4	3	....	7	16
	Total	121	15	89	14	54	....	7	179

The Tarague association comprises **flavea**, **pallida**, and **fulva** adults. The embryonic young of the first-named are yellowish 19 and whitish 17 (fig. 57, plate 11); here there is only a slight preponderance of the **flavea** type among the offspring. The 30 young borne by the **pallida** adults are yellowish 11 (fig. 58, plate 11), whitish 19, thus displaying a definite tendency toward the production of the lighter type. The fulva adults contained 6 yellowish, 1 whitish, and 3 brown young (fig. 59, plate 11). As the flavea adults number 36 in the whole colony to 19 pallida, while the yellowish young amount to 36 as compared with 37 whitish individuals, evidently some of the embryonic flavea snails are so pale as to be indistinguishable from pallida; this conclusion is certainly preferable to the supposition that the association is rapidly changing from one in which flavea is dominant to one characterized by a preponderance of pallida. A second important point is that the majority of the young produced by fulva adults revert to the lighter phases, while the others repeat the parental character of color unmistakably. Obviously the three color-classes of this association interbreed.

The discussion becomes more involved when it shifts to the associations which comprise the darker classes of strigata, strigata-helix, and bicestata, as in the local series from the Apra Region (table 24). Embryonic shells of the three types are shown in figures 60 to 64, plate 11. The strigata form is light brownish with a similar apex (figs. 60, 61, plate 11), and it is quite different from the fulva type of young. In the strigata-helix young there is a definite revolving band on a brownish ground-color (fig. 62, plate 11). The banded pattern of the bicestata young is evident in the actual specimens (figs. 63, 64, plate 11) by virtue of the contrast between the light ground-color and the bands. While errors in determination are by no means entirely excluded, yet the distinctive characters are so clearly displayed by the majority of the young as to render the statistics really significant.

In the eastern Cabras association (table 24), the flavea type reproduces its own kind without exception; this is at least suggestive that the lighter and more uniform coloration is a Mendelian dominant with reference to darker color characters. The strigata adults produce all three kinds of offspring, but with a high preponderance of their own kind, and the same is true of the bicestata adults. The striking features of the western Cabras association are the exclusiveness in heredity of the bicestata pattern, the transmission of the strigata coloration with nearly equal strictness, and the production of both strigata and bicestata young by the strigata-helix parents. In the case of the Orote material, which includes some light but recognizable fulva, an additional point of interest is the lighter color of the young from such adults; undoubtedly some were destined to become darker with age.

From the facts recorded above, even when due allowance is made for unavoidable errors of observation, it is clear that the animals of the distinguishable color-classes are genetically inter-related and have not become so isolated in the physiological sense as to be incapable of mutual interbreeding.

CHAPTER VI.

PARTULA GIBBA Férussac—GUAM.

GENERAL CONSIDERATIONS.

In the *Manual of Conchology*, Pilsbry unites the several species of *Partula* which inhabit the Mariana Islands into a new section of the genus called MARIANELLA, and of this section *Partula gibba* is designated as the type; by virtue of this representative position, its nature and variations are specially significant. It is the most abundant of the four species found in Guam and occurs also in the islands of Saipan and Tinian. Its intrinsic diversification has been carried to a much greater degree than in the case of *radiolata*, both in the variety of the distinctive color-forms and in the geographical localization of such components as well. In all respects, therefore, the present species is the most varied and the most valuable for the study of the problems under investigation.

Partula gibba was first collected by the naturalists of the Freycinet expedition of 1819, and the original examples were described by Férussac in 1821 at the same time that *P. fragilis* was established.[1] There is no question that the type material came from Guam and that it was collected by the botanist Gaudichaud-Beaupré. The zoologists Quoy and Gaimard were also members of this expedition, which explored Tinian and Rota but not Saipan; they returned in 1828 as members of the *Astrolabe* expedition under d'Urville, and were well acquainted with *gibba*, as indicated by their comments cited below. The species is recorded by von Prowazek[2] as an inhabitant of Saipan and Tinian. Whether or not Rota is also the home of *gibba* remains to be determined.

The taxonomic record of *gibba* begins with the original description by Férussac (*loc. cit.*), here given in translation substantially as it appears in Pilsbry's *Manual*:

> Shell conic-ovate, perforate, rather solid, striatulate, pellucid, engraved longitudinally with equal lines, white or flesh-colored, the spire acute, rose-red, the suture milk-white; epidermis thin, rufescent. Whorls 4½, the last swollen, gibbous, larger than the rest. Aperture long-ovate, subquadrangular; peristome reflexed, broadly dilated, white. Var. ruddy-black. Habitat, the Mariana Islands.

In the general account by Freycinet,[3] figures are given of two adult shells and of one very immature individual; the first belongs to a typical color-class hereinafter distinguished as **mitella**, while the second is recognizable as a member of a sharply contrasted color-class, **castanea**. The young shell is not colored.

Quoy and Gaimard describe the animal under the name of *Helix gibba* and repeat the orignal diagnosis of Férussac.[4] They distinguish and figure a variety which is undoubtedly the separate species *P. radiolata*; their statements have been fully discussed in connection with that species and do not require repetition. In commenting on *gibba* these authors say: "This mollusc is very common at Guam, one of the Mariana Islands, although it does not inhabit all parts of the island.

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[1] Férussac, *Tableaux systematiques des animaux mollusques*, etc., p. 66, 1821.
[2] S. von Prowazek, *Die deutsche Marianen*, 1913.
[3] Freycinet, L. de. *Voyage autour du monde de l'Uranie et la Physicienne, zoologie*, p. 485, plate 68, figs. 15, 16, 17, 1824.
[4] Quoy and Gaimard, *Voyage de l'Astrolabe*, vol. 2, p. 113, plate 9, figs. 18 to 20, 1833.

It is in the vicinity of Agaña that it is found in cool places and on the branches of the trees."

Under the name of *Partula mastersi*, in 1857 Pfeiffer described[1] a series of specimens of *gibba* which had been collected in Guam by Cuming. The diagnosis is very general and gives no reasons for excluding the shells in question from Férussac's *gibba*. The colors are given as "buff, fleshy, or violaceous, sometimes banded with brown on the upper whorls." "Peristome . . . . white or fleshy-brown." A variety is distinguished on the basis of violaceous color on the last whorl, and by a small, white, deeply placed tooth within the penultimate whorl. The writer concurs with Pilsbry in the view that *mastersi* is the same species as *gibba*. It will appear beyond that the color differences specified are very secondary and are not even of varietal validity; furthermore, the presence or absence of a weakly developed parietal tooth or callus is likewise a trivial detail.

In 1872 Pease gave the following description of a form from Guam which he called *Partula bicolor*:[2]

Shell solid, perforate, acutely ovate, glossy, transversely marked with close, obsolete striæ, straw-colored, the whorls of the spire encircled with a brownish band next to the suture. Peristome brownish outside and within. Whorls 4, convex, the last half the length of the shell. Peristome thickened, narrowly and equally expanded. Aperture slightly oblique, oval, with a small callus deep within on the body of the penultimate whorl. Length 15, diameter 9 mm.; aperture 5 mm. long, 4 mm. wide. The above may be distinguished from *P. gibba*, which occurs at the same locality, in being of smaller size, last whorl not inflated, and in its color.

Pilsbry recognizes the relation of the above to Férussac's *gibba*, and makes Pease's form a true variety of the original species, commenting as follows:

This form intergrades with *P. gibba*, and should evidently be regarded as sub-species of that, chiefly distinguishable by having the last whorl less swollen than in the typical *gibba*, and by having a callous nodule deep within, on the parietal wall near the columella. This nodule is seen very weakly developed in some examples of *gibba*. Other supposed differences are even less constant . . . The suture may be marked with a whitish line, but often this is absent. No specimen I have seen has a well-developed white band along the suture, such as is usual in *P. gibba*.

Having an extensive series of shells in hand, I find it impossible to use the foregoing distinctions for the separation of *bicolor* as a true variety. It is true that the coloration of Pease's form is sufficiently distinctive to justify the establishment of a color-class; but the white sutural line, less swollen body-whorl, and deep internal nodule do not always accompany the peculiar coloration and are entirely independent of the latter.

One very interesting item in the literature is a quotation given by Smith[3] in his annotations on the Hartman collection; this is an excerpt from a letter which Brazier wrote to Hartman under date of June 18, 1885, as follows:

P. bicolor Pease was described from three specimens sent by me to him. They were picked out by me from three bushels of *P. gibba* from Guam, collected by my late father-in-law, Capt. Rossiter, in a French whaler, 45 years ago.

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[1] Pfeiffer, *Proc. Zool. Society London*, part 25, p. 110, 1857.
[2] W. H. Pease, *Amer. Journ. Conchology*, vol. 7, pp. 26, 27, plate 9, fig. 4.
[3] H. H. Smith, *Annals Carnegie Museum*, vol. 1, p. 439, 1902.

It would seem that while *gibba* must have been very abundant about 1840, the peculiarly colored shells in question were excessively rare; even to-day the latter are scarce in the neighborhood of Agaña, from whose environs most of the earlier collections were secured. But if three bushels were taken in that territory now, there would certainly be many shells of the distinctive pattern, and many specimens of *radiolata* and *fragilis* as well. In several other parts of Guam remote from Agaña, and in Saipan, the type called *bicolor* by Pease is exceedingly abundant.

Pilsbry gives in the *Manual* all of the fundamental statements in the earlier literature and also a full series of figures which illustrate many of the color-forms of this highly-variable species. Necessarily the descriptions are qualitative, save for the few measurements of record, and the color-types are described circumstantially as they are known in the available museum collections or are figured by earlier authors. The material of the present research comprises all of the color types so distinguished by Pilsbry, together with others which greatly facilitate the task of analyzing the whole species into the major classes with their subsidiary divisions. The inter-relationships of these components present problems of a very interesting nature, especially because transitional series and convergent forms occur. Then, besides, in a clearly different category, the distributional relations of the distinguishable color-types require detailed description and elucidation.

Putting aside for the time the material procured in Saipan, as this will be considered separately in a later chapter, we may now take up the species as it was found in Guam. In view of the facts and discussions presented in the earlier chapters, it will suffice here to repeat only the general statement that the species varies throughout Guam in numerical abundance and in the characteristics displayed by the several representative associations, and that in the latter connection the shells differ in their statistical characters as well as in the kinds and relative abundance of the component color-classes.

From 30 of the entire series of localities, 2,404 adult and 804 immature animals were taken; from the former 6,053 young and eggs were dissected. The partly grown individuals are most indispensable for the proper understanding of the color-types, but the embryonic shells are not so generally useful, because many of the distinctive colors and color-patterns are developed only in later life.

VARIATION IN NUMERICAL ABUNDANCE.

The absolute and relative numbers of *Partula gibba* in the several local collections have been duly recorded in the general census table given in Chapter II (table 4). In the case of relative frequency, the approximation of the figures to the real numbers will naturally be closer in the larger collections; where only a few snails were taken, as in many of the localities of the Coast Central Region, the data are valuable mainly as indicating the actual presence of the species in such places. Furthermore, the relative abundance of *gibba* must be considered with due regard to the presence and absolute abundance of associated species like *fragilis* and *radiolata*. In the description of the last-named, all of the essential points in this connection were fully discussed and need not be restated; here we may review only the general features which are specific for *gibba*.

Partula gibba is the dominant species in the western half of Guam, and in most of the territory of the South Central Region as well. It is entirely absent from Cabras Island, and it is infrequent on the Orote Peninsula, judging from the single collection taken thereon. The numbers diminish with the passage to the Southwest Region, and the Inarajan collection comprises none of this species.

The absence of *gibba* from the lower levels of the Ylig and Pago River valleys is noteworthy, because *radiolata* was found in considerable numbers in both localities, while on the adjacent uplands *gibba* flourishes in abundance. The low altitude by itself does not seem to be responsible for its absence from the river gorges in question, because the species occurs at equally low levels on the western side of the island, notably at the Presidio stations and in the Coast Central Region. And higher altitude alone can not be regarded as a favoring factor when the species is so rare on the upper collecting-grounds of the Southwest Region.

Here, again, we can say only that the numbers are sometimes few and sometimes many in territories that seem to possess identical ecological requisites for the occurrence of any Partulæ at all. Apparently innate vigor and a substantial reproductive rate determine the numerical abundance of the species in any locality with suitable vegetation and the vital degrees of shade and moisture.

COLONIAL VARIATION IN QUANTITATIVE CHARACTERS.

The actual collections are sufficiently rich in almost all the localities examined to give reliable statistical definitions of the standard characters of the shells of the different colonies. For the sake of completeness, even the smaller series has been statistically analyzed, and hence the tables of the present section comprise the figures for all of the perfect and measurable shells.

The full quantitative description of the species as it was found in Guam is given in tables 25 to 28. The local series are individually defined and the regional populations are so combined as to afford descriptions of the inhabitants of the more inclusive areas, while finally the figures are recorded for the entire series of shells taken as a single group. The last-mentioned data constitute an accurate quantitative description of the species, and hence they amplify, if they need not replace, the scanty figures and the qualitative terms employed by earlier authors. It would be impossible to obtain a more reliable empirical definition of the species without making a more complete collection from a fuller series of localities.

By way of comment, it is clear that the ample local series, such as those of Tarague, Lolo, and Aniguac, exercise a greater influence upon the general averages than the smaller collections, like those of Saucio, Lonfit, and the southwest stations. This greater weight would be justifiable if the species were actually more abundant in the first-named places, which really seems to be the case; for example, many hours of work in the Umatac territory resulted in very sparse collections of *gibba*, while an hour or two in the Macajna or Fonte localities yielded an abundance of specimens. Only in the cases where a shorter period of field-work accounted for the collection of a smaller series where the species was actually numerous would a real error of under-weighting occur. But no misconception regarding the nature and

TABLE 25.—*Partula gibba, Guam. Statistical description: range of the fundamental characters.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Northeast Region:								
Tarague	291	14.75 – 19.85	10.1 – 13.5	62.5 – 75.5	8.7 – 11.1	6.3 – 8.1	67.5 – 81.5	51.5 – 61.5
Santa Rosa	69	15.95 – 18.35	10.9 – 12.9	65.5 – 74.5	8.9 – 10.3	6.5 – 7.9	69.5 – 79.5	51.5 – 59.5
Asados	140	15.65 – 18.95	10.7 – 13.3	62.5 – 76.5	8.7 – 10.5	6.5 – 8.1	69.5 – 82.5	50.5 – 60.5
Whole region	500	14.75 – 19.85	10.1 – 13.5	62.5 – 76.5	8.7 – 11.1	6.3 – 8.1	67.5 – 82.5	50.5 – 61.5
East Central Region:								
Lolo	222	14.45 – 18.35	9.3 – 12.7	63.5 – 74.5	8.3 – 10.3	6.1 – 7.7	68.5 – 78.5	53.5 – 59.5
Barrigarda	182	15.05 – 18.05	10.5 – 13.3	64.5 – 74.5	8.7 – 10.7	6.5 – 7.9	69.5 – 78.5	52.5 – 61.5
Ukudu	71	15.95 – 20.15	10.5 – 13.5	62.5 – 76.5	9.1 – 11.3	6.7 – 8.3	68.5 – 78.5	53.5 – 59.5
Dededo	102	16.25 – 18.65	11.1 – 13.5	63.5 – 75.5	9.1 – 10.7	6.5 – 7.9	69.5 – 79.5	54.5 – 61.5
Saucio	12	16.55 – 18.65	11.3 – 12.5	65.5 – 72.5	9.5 – 10.5	6.9 – 7.7	71.5 – 77.5	55.5 – 58.5
Whole region	589	14.45 – 20.15	9.3 – 13.5	62.5 – 76.5	8.3 – 11.3	6.1 – 8.3	68.5 – 79.5	52.5 – 61.5
South Central Region:								
Ylig, upper	120	15.35 – 18.05	10.7 – 13.1	63.5 – 73.5	8.5 – 10.5	6.5 – 7.7	69.5 – 77.5	53.5 – 60.5
Pago, north	71	15.95 – 18.65	11.1 – 13.5	65.5 – 74.5	9.3 – 10.9	6.9 – 8.3	68.5 – 81.5	54.5 – 60.5
Lonfit	15	17.75 – 19.25	11.7 – 12.7	64.5 – 69.5	9.9 – 10.7	7.1 – 7.5	69.5 – 74.5	53.5 – 57.5
Ordot	29	16.25 – 18.05	11.1 – 12.7	67.5 – 73.5	9.3 – 10.3	6.9 – 7.5	69.5 – 76.5	54.5 – 60.5
Macajna, second	134	15.05 – 18.05	10.5 – 12.9	64.5 – 74.5	8.7 – 10.3	6.3 – 7.7	66.5 – 78.5	53.5 – 60.5
Macajna, first	16	16.25 – 18.65	11.3 – 12.7	66.5 – 72.5	9.1 – 10.3	7.1 – 7.7	71.5 – 77.5	55.5 – 59.5
Fonte A	202	15.65 – 18.65	10.5 – 13.1	64.5 – 74.5	8.9 – 10.7	6.3 – 7.7	67.5 – 79.5	53.5 – 60.5
Fonte B	75	15.35 – 18.35	9.9 – 12.5	61.5 – 72.5	8.7 – 10.5	6.1 – 7.7	67.5 – 74.5	53.5 – 59.5
Asan	38	15.65 – 18.65	10.5 – 12.7	65.5 – 72.5	8.7 – 10.3	6.3 – 7.5	69.5 – 77.5	53.5 – 57.5
Whole region	700	15.05 – 19.25	9.9 – 13.5	61.5 – 75.5	8.5 – 10.9	6.1 – 8.3	66.5 – 81.5	53.5 – 60.5
Coast Central Region:								
Tumon	2	17.15 – 17.45	11.7 – 11.9	66.5 – 69.5	9.9 – 10.1	7.1 – 7.3	70.5 – 73.5	56.5 – 58.5
Oco	14	15.95 – 17.45	10.3 – 11.9	64.5 – 71.5	8.7 – 10.1	6.3 – 7.3	72.5 – 79.5	52.5 – 58.5
Timoneng	15	15.65 – 17.45	10.7 – 11.9	67.5 – 72.5	8.9 – 10.3	6.5 – 7.5	69.5 – 77.5	55.5 – 60.5
Dungcas	33	15.65 – 18.05	10.5 – 12.5	63.5 – 74.5	9.3 – 10.5	6.7 – 7.7	69.5 – 76.5	56.5 – 61.5
Agaña	29	15.95 – 18.95	11.1 – 13.1	66.5 – 74.5	9.1 – 10.7	6.7 – 7.7	70.5 – 79.5	52.5 – 62.5
Aniguac	219	14.75 – 18.95	9.9 – 13.3	62.5 – 74.5	8.5 – 10.9	6.3 – 7.9	68.5 – 77.5	51.5 – 61.5
Cemetery	38	15.05 – 18.95	10.1 – 13.1	65.5 – 72.5	8.7 – 10.7	6.5 – 7.9	68.5 – 80.5	53.5 – 60.5
Presidio, outer	30	15.35 – 18.05	10.9 – 12.9	66.5 – 74.5	9.3 – 10.3	6.7 – 7.7	69.5 – 76.5	54.5 – 61.5
Presidio, inner	62	15.05 – 17.45	10.7 – 12.3	67.5 – 74.5	8.7 – 10.1	6.5 – 7.3	71.5 – 78.5	54.5 – 59.5
Whole region	442	14.75 – 18.95	9.9 – 13.3	62.5 – 74.5	8.5 – 10.9	6.3 – 7.9	68.5 – 80.5	51.5 – 62.5
Apra Region:								
Orote	19	15.95 – 17.45	11.5 – 13.1	68.5 – 76.5	9.3 – 10.3	6.7 – 7.7	71.5 – 77.5	55.5 – 60.5
West Central Region:								
Agat	6	15.95 – 17.75	11.3 – 12.1	65.5 – 71.5	9.1 – 10.3	6.7 – 7.5	70.5 – 75.5	56.5 – 59.5
Salifan	86	15.95 – 19.25	11.1 – 13.1	64.5 – 73.5	9.1 – 10.9	6.7 – 7.9	69.5 – 77.5	54.5 – 60.5
Southwest Region:								
Umatac Salonga	7	16.85 – 18.05	11.1 – 11.9	64.5 – 69.5	9.7 – 9.9	6.9 – 7.3	69.5 – 73.5	54.5 – 57.5
Umatac Pajom	9	17.15 – 18.35	11.9 – 12.9	66.5 – 70.5	9.7 – 10.5	7.1 – 7.7	70.5 – 76.5	53.5 – 57.5
Umatac Madog	6	17.45 – 18.05	11.7 – 12.3	67.5 – 69.5	9.3 – 10.1	6.9 – 7.5	71.5 – 75.5	53.5 – 56.5
Merizo	1	17.45	12.5	71.5	10.1	7.3	73.5	57.5
Whole region	23	16.85 – 18.35	11.1 – 12.9	64.5 – 71.5	9.3 – 10.5	6.9 – 7.7	69.5 – 76.5	53.5 – 57.5
Whole island	2365	14.45 – 20.15	9.3 – 13.5	61.5 – 76.5	8.3 – 11.3	6.1 – 8.3	66.5 – 82.5	50.5 – 62.5

TABLE 26.—*Partula gibba, Guam. Statistical description: mean values of the fundamental characters.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Northeast Region:								
Tarague	291	17.1005±.0303	11.9137±.0226	69.6065±.0906	9.7289±.0158	7.2588±.0122	74.4863±.0828	56.7784±.0585
Santa Rosa	69	17.0630±.0445	11.8449±.0346	69.2826±.1455	9.6014±.0242	7.1406±.0239	74.0362±.1713	56.1232±.1132
Asados	140	17.2250±.0348	11.9214±.0273	69.1715±.1382	9.6343±.0197	7.1472±.0195	73.9857±.1277	55.7857±.0774
Whole region	500	17.1302±.0211	11.9064±.0159	69.4400±.0687	9.6848±.0114	7.2112±.0097	74.2840±.0649	56.4100±.0453
East Central Region:								
Lolo	222	16.4527±.0277	11.3937±.0241	69.1576±.0932	9.3540±.0163	6.8279±.0130	72.8648±.0804	56.7432±.0613
Barrigarda	182	16.8648±.0295	11.7385±.0258	69.5330±.1021	9.7088±.0195	7.1275±.0153	73.2912±.0936	57.4066±.0813
Ukudu	71	17.5684±.0617	12.0465±.0413	68.7535±.2114	9.9253±.0327	7.2437±.0222	73.0493±.1693	56.2465±.1122
Dededo	102	17.3971±.0392	12.1804±.0360	70.1471±.1552	9.9235±.0234	7.3353±.0216	73.8921±.1310	56.9216±.0987
Saucio	12	17.5250±.1219	11.9500±.0658	68.1667±.3671	10.0000±.0515	7.3000±.0420	73.0000±.3599	57.0000±.1864
Whole region	589	16.8999±.0209	11.7265±.0168	69.3761±.0618	9.6443±.0123	7.0681±.0100	73.1995±.0533	56.9244±.0420
South Central Region:								
Ylig, upper	120	16.8300±.0366	11.8733±.0306	70.4750±.1319	9.7150±.0229	7.1250±.0175	73.2750±.1076	57.6167±.0868
Pago, north	71	17.4035±.0486	12.2211±.0415	70.8887±.1797	10.0099±.0272	7.3873±.0240	73.7958±.1939	57.4014±.1157
Lonfit	15	18.4300±.0750	12.3933±.0438	66.9667±.2688	10.2467±.0347	7.3667±.0208	71.8333±.2434	55.3000±.1929
Ordot	29	17.1810±.0578	12.0241±.0515	69.9827±.2058	9.7483±.0333	7.1552±.0217	73.2249±.2103	56.6734±.1473
Macajna, second	134	16.7224±.0407	11.7075±.0307	69.9891±.1272	9.5925±.0224	7.0343±.0174	73.3508±.1131	57.2388±.0889
Macajna, first	16	17.3933±.1093	12.0125±.0756	69.1875±.2778	9.8750±.0544	7.3875±.0376	74.5625±.2949	56.9375±.1882
Fonte A	202	17.1707±.0298	11.8084±.0214	68.6527±.0795	9.7847±.0162	7.0291±.0134	71.8202±.0831	56.7857±.0558
Fonte B	75	16.7140±.0519	11.1693±.0440	66.7000±.1656	9.4893±.0266	6.7507±.0247	70.8200±.1275	56.7000±.0986
Asan	38	17.0316±.0646	11.8368±.0438	68.3158±.1848	9.5579±.0385	6.9632±.0284	72.6842±.0268	55.9736±.1346
Whole region	700	17.0261±.0179	11.7903±.0142	69.1900±.0589	9.7251±.0098	7.0700±.0084	72.6243±.0535	56.9914±.0361
Coast Central Region:								
Tumon	2	17.3000±.0715	11.7000±.0477	68.0000±.7154	10.0000±.0477	7.2000±.0477	72.0000±.7154	57.5000±.4769
Oco	14	16.7000±.0836	11.3714±.0662	67.9286±.4072	9.3000±.0578	6.9428±.0475	74.6428±.3531	55.6428±.2797
Timoneng	15	16.4700±.0884	11.4467±.0589	69.4333±.2501	9.6066±.0608	7.0733±.0506	73.5667±.4144	58.3000±.2577
Dungcas	33	16.6954±.0678	11.6151±.0557	69.5606±.2947	9.7182±.0376	7.1485±.0271	73.4394±.2219	58.2576±.1475
Agaña	29	16.9845±.0722	11.9414±.0453	70.4311±.2324	9.6379±.0451	7.2379±.0302	74.8448±.2777	56.7068±.2357
Anignac	219	17.1089±.0344	11.8534±.0262	69.2078±.0918	9.7877±.0203	7.1192±.0150	72.5822±.0884	57.1393±.0806
Cemetery	38	16.6053±.0793	11.5210±.0602	69.2895±.1947	9.5526±.0516	7.0790±.0375	74.0263±.2494	57.4737±.1748
Presidio, outer	30	17.0800±.0686	11.8200±.0499	69.3667±.2597	9.8067±.0322	7.1733±.0301	73.1000±.2147	57.4333±.2441
Presidio, inner	62	16.0855±.0461	11.3548±.0339	70.6774±.1354	9.2452±.0254	6.9516±.0201	75.1459±.1444	57.4194±.1035
Whole region	442	16.8473±.0245	11.7113±.0175	69.5000±.0662	9.6570±.0142	7.0991±.0099	73.4095±.0704	57.2760±.0553
Apra Region:								
Orote	19	16.6763±.0644	12.1210±.0687	72.3421±.2573	9.7421±.0433	7.2684±.0417	74.5526±.2432	58.1842±.1813
West Central Region:								
Agat	6	16.7000±.1952	11.6667±.0922	69.1666±.5192	9.7000±.1189	7.1000±.0841	72.8333±.4943	57.5000±.3179
Salifan	86	17.3419±.0433	12.0651±.0338	69.6046±.1293	9.9488±.0286	7.3279±.0222	73.5930±.1287	57.3372±.1028
Whole region	92	17.3000±.0502	12.0391±.0329	69.5761±.1258	9.9326±.0282	7.3130±.0218	73.5435±.1252	57.3478±.0983
Southwest Region:								
Umatac Salonga	7	17.3643±.1059	11.5572±.0534	66.3572±.4400	9.8429±.0230	7.0429±.0357	71.7857±.4859	56.0714±.2676
Umatac Pajom	9	17.7500±.0779	12.3000±.0670	69.2777±.2956	10.0555±.0591	7.4555±.0412	74.1666±.3671	56.5000±.2596
Umatac Madog	6	17.6500±.0616	12.0000±.0572	67.8333±.2052	9.8333±.0757	7.2667±.0587	73.8333±.3784	55.3333±.2938
Merizo	1	17.4500	12.5000	71.5000	10.1000	7.3000	73.5000	57.5000
Whole region	23	17.5935±.0526	12.0044±.0574	68.1087±.2711	9.9348±.0348	7.2739±.0345	73.3261±.2511	56.1087±.1697
Whole island	2365	16.9966±.0102	11.7986±.0078	69.3770±.0310	9.6940±.0057	7.1178±.0047	73.3233±.0302	56.9199±.0215

TABLE 27.—*Partula gibba, Guam. Statistical description: standard deviations of the fundamental characters.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Northeast Region:								
Tarague	291	0.7666±.0214	0.5711±.0160	2.2912±.0640	0.4010±.0112	0.3092±.0086	2.0939±.0585	1.4788±.0413
Santa Rosa	69	.5479±.0314	.4265±.0244	1.7926±.1029	.2981±.0171	.2940±.0169	2.1099±.1211	1.3946±.0800
Asados	140	.6107±.0246	.4791±.0193	2.4244±.0977	.3459±.0139	.3428±.0138	2.2408±.0903	1.3590±.0547
Whole region	500	.7011±.0149	.5289±.0112	2.2769±.0486	.3770±.0080	.3219±.0068	2.1516±.0459	1.5026±.0320
East Central Region:								
Lolo	222	.6131±.0196	.5324±.0170	2.0599±.0659	.3596±.0115	.2889±.0092	1.7775±.0568	1.3538±.0433
Barrigarda	182	.5869±.0208	.5166±.0182	2.0424±.0722	.3910±.0138	.3058±.0108	1.8724±.0662	1.6264±.0575
Ukudu	71	.7710±.0436	.5167±.0292	2.6416±.1495	.4083±.0231	.2772±.0157	2.1149±.1197	1.4014±.0793
Dededo	102	.5872±.0277	.5396±.0254	2.3248±.1097	.3502±.0165	.3234±.0153	1.9612±.0926	1.4782±.0698
Saucio	12	.6260±.0862	.3379±.0465	1.8856±.2596	.2646±.0364	.2160±.0297	1.8484±.2545	0.9574±.1318
Whole region	589	.7537±.0148	.6042±.0119	2.2235±.0437	.4443±.0087	.3587±.0071	1.9185±.0377	1.5105±.0297
South Central Region:								
Ylig, upper	120	.5964±.0259	.4966±.0216	2.1427±.0932	.3716±.0162	.2847±.0124	1.7486±.0761	1.4094±.0614
Pago, north	71	.6076±.0344	.5184±.0293	2.2449±.1270	.3403±.0192	.2997±.0170	2.4229±.1371	1.4453±.0818
Lonfit	15	.4308±.0530	.2516±.0310	1.5434±.1901	.1996±.0245	.1193±.0147	1.3980±.1721	1.1075±.1364
Ordot	29	.4617±.0409	.4116±.0364	1.6436±.1455	.2660±.0235	.1733±.0153	1.6795±.1487	1.1763±.1041
Macajna, second	134	.6992±.0288	.5277±.0217	2.1836±.0899	.3845±.0158	.2990±.0123	1.9413±.0800	1.5255±.0628
Macajna, first	16	.6482±.0773	.4484±.0534	1.6477±.1964	.3230±.0384	.2233±.0266	1.7488±.2085	1.1163±.1331
Fonte A	202	.6278±.0211	.4519±.0151	1.6761±.0562	.3414±.0114	.2823±.0095	1.7507±.0587	1.1769±.0394
Fonte B	75	.6651±.0367	.5643±.0311	2.1229±.1171	.3408±.0188	.3168±.0174	1.6483±.0901	1.2649±.0697
Asan	38	.5902±.0457	.4003±.0310	1.6895±.1307	.3521±.0272	.2599±.0201	1.8898±.1462	1.2299±.0952
Whole region	700	.7041±.0126	.5596±.0100	2.3107±.0416	.3864±.0069	.3284±.0059	2.0977±.0378	1.4157±.0255
Coast Central Region:								
Tumon	2	.1500±.0502	.1000±.0337	1.5000±.5058	.1000±.0337	.1000±.0337	1.5000±.5058	1.0000±.3372
Oco	14	.4641±.0591	.3673±.0468	2.2588±.2879	.3207±.0409	.2638±.0336	1.9857±.2497	1.5518±.1978
Timoneng	15	.5075±.0625	.3383±.0416	1.4360±.1768	.3492±.0430	.2909±.0358	2.3795±.2930	1.4697±.1822
Dungcas	33	.5774±.0479	.4749±.0394	2.5098±.2084	.3204±.0266	.2311±.0191	1.8899±.1569	1.2560±.1043
Agaña	29	.5767±.0510	.3615±.0320	1.8557±.1643	.3605±.0319	.2413±.0213	2.2171±.1963	1.8824±.1666
Aniguac	219	.7541±.0243	.5761±.0185	2.0151±.0649	.4450±.0143	.3302±.0106	1.9404±.0625	1.7679±.0570
Cemetery	38	.7246±.0561	.5502±.0425	1.7794±.1377	.4717±.0365	.3427±.0265	2.2796±.1763	1.5975±.1236
Presidio, outer	30	.5569±.0485	.4053±.0353	2.1092±.1836	.2619±.0227	.2449±.0213	1.7435±.1518	1.9821±.1726
Presidio, inner	62	.5379±.0326	.3954±.0240	1.5814±.0957	.2966±.0179	.2354±.0142	1.6859±.1021	1.2088±.0732
Whole region	442	.7644±.0173	.5469±.0124	2.0646±.0468	.4444±.0100	.3079±.0070	2.1964±.0498	1.7247±.0391
Apra Region:								
Orote	19	.4165±.0455	.4444±.0486	1.6627±.1819	.2797±.0306	.2696±.0295	1.5719±.1719	1.1721±.1282
West Central Region:								
Agat	6	.7089±.1380	.3349±.0652	1.8856±.3671	.4320±.0841	.3055±.0594	1.7951±.3495	1.1547±.2248
Salifan	86	.6952±.0306	.4647±.0239	1.7786±.0914	.3941±.0202	.3052±.0157	1.7694±.0910	1.4131±.0727
Whole region	92	.7139±.0355	.4679±.0232	1.7891±.0889	.4014±.0199	.3104±.0154	1.7810±.0885	1.3982±.0695
Southwest Region:								
Umatac Salonga	7	.4155±.0749	.2096±.0377	1.7262±.3111	.0904±.0162	.1400±.0252	1.9059±.3463	1.0498±.1892
Umatac Pajom	9	.3464±.0551	.2981±.0474	1.3147±.2090	.2629±.0418	.1833±.0291	1.6329±.2596	1.1547±.1835
Umatac Madog	6	.2236±.0435	.1915±.0372	0.7453±.1451	.2749±.0535	.2134±.0415	1.3744±.2675	1.0673±.2077
Merizo	1	....	....	....	....	....	....	....
Whole region	23	.3739±.0372	.4080±.0406	1.9278±.1917	.2478±.0246	.2453±.0244	1.7852±.1775	1.2065±.1200
Whole island	2365	.7364±.0072	.5649±.0055	2.3336±.0219	.4146±.0040	.3373±.0033	2.1777±.0213	1.5500±.0152

TABLE 28.—*Partula gibba, Guam. Progressive regional comparisons.*

Region.	Mean Value, Differences.						
	Shell.			Aperture.			Length aperture + length shell, proportions.
	Length.	Width.	Proportions.	Length.	Width.	Proportions.	
	mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Northeast...... / East Central....	−.2303±.0297	−.1799±.0231	[−.0639±.0924]	[−.0405±.0168]	−.1431±.0139	−1.0845±.0840	+.5144±.0618
East Central.... / South Central...	+.1262±.0275	[+.0638±.0222]	[−.1861±.0854]	+.0808±.0157	[+.0019±.0131]	−.5752±.0755	[+.0670±.0554]
South Central... / Coast Central...	−.1788±.0303	−.0790±.0225	+.3100±.0886	−.0687±.0172	[+.0291±.0130]	+.7852±.0884	+.2846±.0660
East Central.... / Coast Central...	[−.0526±.0302]	[−.0152±.0243]	[+.1239±.0906]	[−.0127±.0188]	[+.0310±.0141]	[+.2100±.0883]	+.3516±.0694
Coast Central... / Apra...........	[−.1710±.0689]	+.4097±.0709	+2.8421±.2657	[+.0851±.0456]	+.1693±.0428	+1.1431±.2532	+.9082±.1895
Apra........... / West Central...	+.6237±.0817	[−.0819±.0762]	−2.7660±.2864	+.1905±.0517	[+.0454±.0471]	−1.0091±.2735	−.8364±.2062
West Central... / Southwest......	+.2935±.0727	[−.0248±.0662]	−1.4674±.2989	[+.0022±.0448]	[−.0391±.0408]	[−.2174±.2806]	−1.2391±.1956

value of the summary figures need arise in view of the present precise statement as to what they mean.

If every association should have exactly the same weight as any other, regardless of the numbers in each, the average of the colonial averages is a different figure with a different biological significance. By way of concrete illustration, the character of shell-length comes out variously according to the method of its determination. When the shells are all combined into a single series, the value is 16.9968 mm. as tabulated; the regional averages, when accorded equal weight, give 17.0634 mm. as their mean; and if the colonial averages are treated as though they had the same significance, their general average is 17.0921 mm. In my own opinion, the first determination is nearer to the real value of this character in the species, because in general the weights to be assigned to the several component groups are more fairly estimated by the actual numbers collected than by any other method, and because the number of colonial groups is large enough for errors in one direction to be offset to some degree by errors of the opposite sign.

The figures for the characters of the combined regional populations disclose some interesting relations. The areas with the largest shells are the far-separated Northeast and Southwest Regions, *which display clearly contrasted ecological characters of soil and vegetation.* Furthermore, the lowest regional averages in shell length are those of the Coast Central and East Central territories, *with very different barometric levels.* The Northeast and East Central Regions adjoin and their environmental characters are essentially alike, and yet in the absolute measures of shell length their *gibba* populations are distinctly different. If the analysis is made on the basis of other characters of the shells, the same result is obtained, namely, that the ecological qualities of the surroundings as such are not responsible for the characters of size and shape of the shells borne by the snails which inhabit one region or another. The figures for the inter-regional differences with their probable errors are given in table 28; it is true that the differences indicated are statistically significant in fewer instances than in the similar study of *radiolata*, but their essential meaning is identical.

A detailed examination of the local series and of their differences may be carried out circumstantially to a lesser or greater extent, according to one's interest in the facts of diversification in different areas. It is profitable to compare neighboring series in one and the same region with identical ecological conditions, to discover the degree of difference that may exist, as in the case of the two Macajna or the two Presidio series; and it is also interesting to ascertain that with the passage from a low to a high level, or from a limestone territory to an area of volcanic nature, there are no invariable and consistent changes in the absolute or proportionate characters of the shells.

Extracting a few specific data from the tabulations, the colony with the lowest average length of the shell is that from the inner Presidio, but the shortest individual is from Lolo (fig. 33, plate 13). The highest colonial average for this character is found in the Lonfit group, while the longest single specimen is from Ukudu (fig. 4, plate 13). The lowest colonial width is that of Fonte B and the highest is again that of Lonfit; the narrowest shell is from Lolo (again fig. 33, plate 13) and the widest measure is displayed equally by specimens from Tarague, Ukudu, Dededo, and Pago North. The slenderest shell is one with a value of 61 per cent from Fonte B, and the stoutest specimens, disregarding absolute length, are from Asados and Ukudu, 76 per cent; but the lowest and highest colonial averages are those of Umatac Salonga and Orote respectively. The characters of the aperture and the relations of the aperture to the whole shell may be worked out in the same way. Plates 12 and 13 display many combinations of extreme and average conditions of the several quantitative characters of the shells.

While individual fluctuations may occur in any or in all of the features under consideration, their existence does not invalidate the conclusion that environmental circumstances as such are virtually negligible in comparison with the genetic factors that are ultimately responsible for the individual, colonial, and regional statistical characters, and for those of the whole collection taken as a comprehensive group.

COLOR-CLASSES AND THEIR COLONIAL DISTRIBUTION.

Were the material less ample and less diversified, it would be possible to deal concurrently with the qualitative and the quantitative characters of the color-types into which the species as a whole is differentiated; but, as in the case of *radiolata*, it is necessary first to distinguish and describe the several color-classes, at the same time recording their geographical locations and frequencies. The statistical characters are relegated to a later section—a procedure that is warrantable because such qualities are practically independent of color and coloration. It is true that the ranges of variation and the mean values may not coincide when two color groups are compared, but there is no consistent correlation between an average size and a particular kind of pattern like that claimed in the literature for Pease's *bicolor*.

Partula gibba of Guam surpasses all other species of Micronesia in the number and variety of its color-components, and is fully the equal in such respects of some of the highly diversified species of the Society Islands, where the genus maintains its present headquarters. No less than seven primary *color-classes* are distinguishable which differ mutually to various degrees; the contrast is very sharp in some comparisons, while in others the distinctions are less marked and variants of one class approach nearly to another. Furthermore, the members of four of these classes resolve themselves into clear secondary sections, which will be consistently designated *color-orders* to distinguish them in scope from the primary groups.

TABLE 29.—*Partula gibba. Census of the color-classes and color-orders, Guam.*

Locality.	Total No.	uni-color.	bicolor.	mitella.	mitella-rubra.	phæa-		castanea-		vespera-		mar-ginata.
						rubra.	purpurea.	rubra.	purpurea.	rosea.	cyanea.	
Northeast Region:												
Tarague	292	80	82	102	19	6	3	....	....	....	....	....
Santa Rosa	72	....	1	25	....	45	1	....	....	....	....	....
Asados	140	....	4	....	65	34	37	....	....	....	....	....
East Central Region:												
Lolo	224	70	....	47	....	56	....	....	....	51	....	....
Barrigarda	187	....	....	34	13	29	....	....	....	111	....	....
Ukudu	73	....	....	55	17	1	....	....	....	....	....	....
Dededo	102	....	....	43	47	3	3	2	....	2	2	....
Saucio	12	....	....	6	3	1	1	....	....	1	....	....
South Central Region:												
Ylig, upper	120	....	....	120	....	....	....	....	....	....	....	....
Pago North	71	....	....	31	13	....	....	....	12	1	14	....
Lonfit	17	....	....	....	17	....	....	....	....	....	....	....
Ordot	29	....	8	21	....	....	....	....	....	....	....	....
Macajna 2d	139	....	....	76	22	18	7	3	4	8	1	....
Macajna 1st	16	....	....	10	6	....	....	....	....	....	....	....
Fonte A	205	....	10	140	31	....	....	....	15	2	7	....
Fonte B	76	....	2	57	....	....	....	....	7	....	10	....
Asan	39	....	5	27	5	....	....	....	....	....	2	....
Coast Central Region:												
Tumon	2	....	....	2	....	....	....	....	....	....	....	....
Oco	14	....	2	7	1	....	....	....	....	2	2	....
Timoneng	16	....	4	8	4	....	....	....	....	....	....	....
Dungcas	35	....	....	28	1	....	....	....	....	....	....	6
Agaña	29	....	....	29	....	....	....	....	....	....	....	....
Aniguac	222	....	21	194	....	....	....	2	1	....	4	....
Cemetery	39	....	....	39	....	....	....	....	....	....	....	....
Presidio, inner	65	....	....	65	....	....	....	....	....	....	....	....
Presidio, outer	33	....	....	33	....	....	....	....	....	....	....	....
Apra Region:												
Orote	19	....	....	19	....	....	....	....	....	....	....	....
West Central Region:												
Agat	6	....	....	6	....	....	....	....	....	....	....	....
Salifan	86	....	1	85	....	....	....	....	....	....	....	....
Southwest Region:												
Umatac Salonga	7	....	7	....	....	....	....	....	....	....	....	....
Umatac Pajom	9	....	9	....	....	....	....	....	....	....	....	....
Umatac Madog	7	....	7	....	....	....	....	....	....	....	....	....
Merizo	1	....	1	....	....	....	....	....	....	....	....	....
Summary	2,404	150	164	1,309	264	193	52	7	39	178	42	6

The fundamental statistics in the present connection are given for the entire collection of adult shells in the form of a complete census of the color-types (table 29) with the numbers actually taken and the proper geographical assignments. What are regarded as the probable inter relationships of the color-classes and color-orders are shown in diagrammatic form in text-figure 4.

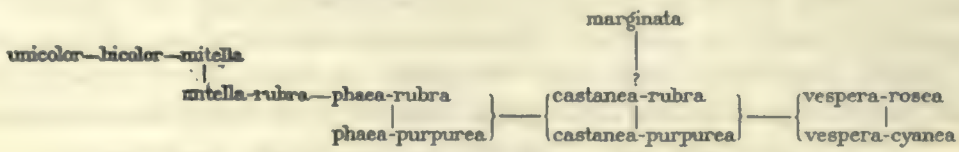


FIG. 4.—*Partula gibba*, Guam, probable interrelations of color classes and color-orders.

At the very outset, it is evident that the color constitution of the several local series varies to an extraordinary degree. In very few places is there only a single color-type and, when this is the case, it is not always the same kind. The color components reach their highest number at Macajna second, where no less than eight occur. In addition, the relative numbers of the color-classes vary from locality to locality, thus accentuating the colonial differences as regards coloration. The several classes now to be described are not taken up in any geographical sequence, but on the basis of their own distinctive peculiarities, from the lightest and simplest to the darker and more complex.

unicolor.—This form is so named on account of its uniformity and simplicity (figs. 1 to 14, plate 12). It was found in abundance in two places, Tarague and Lolo, and it was consistently absent from all other stations, even where its close relative **bicolor** was present. The Tarague shells are corneous-yellow or straw-colored, varying somewhat from lighter to darker shades (figs. 1 to 4, 7, plate 12); in very few examples is the color darkened by an admixture of brown. The inner wall of the shell is similar to the outer (fig. 7, plate 12). In a considerable number the shell is greatly altered by decortication (figs. 5, 6, plate 12) and in the extreme cases it is virtually white with a dull surface, owing to the complete loss of the shining epidermis. The adolescents are fully colored (fig. 8, plate 12) showing that decortication takes place, if at all, only when the animal reaches maturity.

In sharp contrast with the Tarague shells, the **unicolor** of Lolo are pale corneous with only the slightest addition of yellow in exceptional individuals (fig. 9 to 14, plate 12), yet the yellowest Lolo shell is still paler than the lightest Tarague specimen and there is no overlapping. The immature individuals of Lolo are consistently pallid like the adults (fig. 14, plate 12). In the first analysis of **unicolor** the two series in question were given distinctive ordinal names which referred to their respective stramineous and pallid shades of color; while these terms have been omitted for the sake of condensation, the distinctions require due emphasis, especially because associated classes of the two localities, notably **mitella**, also differ correspondingly.

In the shells of both regions, the lip is predominantly white (see table 31, next section). As a final point, the white border below the suture varies greatly in width and distinctness, as the illustrations clearly demonstrate; in this respect unicolor agrees with other classes and gives no reasons for assorting the shells into two subordinate groups with narrower and wider white borders respectively.

bicolor.—The second class is called bicolor because its members display the coloration regarded by Pilsbry as typical for the var. *bicolor* of Pease; no confusion need arise from the employment of the identical word in different senses when it is explicitly stated that it is here used to designate a color-class.

This group stands close to the preceding, with which it agrees in the general ground-color and in its interior tints. The chief difference is that bicolor possesses a revolving band of deeper color on the uppermost whorls (figs. 15 to 24, plate 12). This band varies from yellow to orange-brown; its upper border is vague, but the sutural boundary offers a sharper contrast with the paler portion of the adjacent whorl below. The lip is stained with light yellow, yellowish brown, or orange-brown, although in some instances it is white as in unicolor (table 31 of next section). There seems to be some correlation between the distinctive band and the lip as regards the depth of color (compare figs. 17 and 18, 22 and 23, plate 12), but this is not absolute.

The Tarague bicolor are straw-yellowish corneous, like their unicolor and mitella associates, and the few other specimens taken in the Northeast Region at Asados and Santa Rosa agree with them. In all other places bicolor is more pallid. Decortication occurs in a considerable number of individuals, always later in life, for the adolescent examples (fig. 20, plate 12) never display its effects. A Tarague shell so altered (for example the shell of figure 16, plate 12) may come to resemble the pallid kinds of other regions, but is of course really different in nature. In the early stages, the bicolor shells do not show the revolving band with clearness; this feature becomes intensified as maturity approaches, and consequently it is not possible to assort the unicolor and bicolor adolescents with certainty when the two kinds occur in the same association, as at Tarague.

The collections from 15 localities comprise bicolor shells, but the areas in question are by no means in geographical sequence (consult table 29). Far to the extreme northwest the type occurs in considerable absolute and relative numbers, while it constitutes the sole representation of its species in the Southwest Region at the other end of Guam, where, it will be recalled, the shells are extraordinarily large (fig. 24, plate 12). In the intervening territory it is found only locally and in sparse numbers for the most part, judging as we must from the actual collections. Certainly the figures are significant in the comparison of the Fonte-Asan territory with the two Macajna areas. A final point is the noteworthy fact that bicolor is lacking in the Lolo series, in which unicolor is so largely represented.

mitella.—By far the largest number of *gibba* in Guam display the "hooded" coloration which is indicated by the chosen designation, mitella (figs. 25 to 44, plate 12). This is Férussac's original type, and Pilsbry also recognizes its primacy; apparently Férussac's figures were made from a decorticated specimen with the typical yellowish tint of the body greatly altered.

Again we begin with the Tarague shells in which the general ground-color is corneous with a considerable amount of yellow, as in the associated unicolor and bicolor. The distinctive feature of the class is the tinted spire, which ranges in color from light orange through orange-red to orange-red-brown (figs. 25 to 35, plate 12) or "dull scarlet," to use Pilsbry's phrase. The inner surface of the shell is lighter than the outer. A yellowish or yellowish-brown tinge extends over the flaring lip in most instances, as in bicolor. When the shell is decorticated (figs. 32, 33, plate 12) the spire is dull scarlet rather than orange-red. The apical colors are always lighter in adolescent individuals and deepen with advancing age (figs. 34, 35, plate 12).

In the Lolo colony, the mitella shells are uniformly more pallid, owing to the reduction of the yellow element (figs. 36, 37, plate 12). More rarely in other localities the ground-color is deeper yellow-brown, and in such cases the color of the spire is correspondingly intensified (figs. 38, plate 12); the specimen of the illustration is from Dededo, and by way of contrast a fully decorticated and white-lipped mitella from the same area is figured (fig. 39, plate 12).

Wherever mitella occurs in the southward territories, its general ground-color is less yellowish and more deeply brown, while the spire also is darker, verging toward purplish chestnut (fig. 40, plate 12); if such a shell should become decorticated, its body-whorl is a peculiarly dull and attenuated red in color, thus suggesting the distinct type dealt with later as mitella-rubra (fig. 41, plate 12). Finally, at Salifan are found mitella shells which are invariably dull corneous brown with deeply colored, purple-brown spires (fig. 42 to 44, plate 12). Thus the southernmost shells of this class are the most extreme variants in the direction of deepened color, as compared with the northernmost Tarague shells, which are the lightest and yellowest; but the colonies that lie between do not display any consistent intergradations from the one to the other extreme.

The salient feature of the geographical distribution of mitella is that this class is the most abundant and the most widespread. Taking the island as a whole, more than 54 per cent of all adult shells fall within its bounds; this is all the more significant when we recall that there are no less than six other primary color-classes in the species. While mitella predominates in the majority of the local collections, there are exceptions, as at Santa Rosa and Lolo; its absence from the Asados area is anomalous. Toward the south, at about the Salifan-Ylig transverse zone, mitella is the sole representative of its species; still further south it disappears, so far as the actual collections are concerned, and it is replaced by sparse numbers with the bicolor pattern.

mitella-rubra.—The present group is less clearly defined than any other; only after repeated efforts to devise a more satisfactory arrangement of its members has it finally been established as a color-order, closely related to mitella, but distinguished as mitella-rubra on account of the reddish suffusion over the last whorl (figs. 45 to 56, plate 12). While it may not be a unitary group like the others, yet for descriptive purposes we may accord it ordinal status.

At one extreme we have the shells of Macajna second (figs. 45 to 48, plate 12), which are fundamentally like mitella, but the older part of the last whorl is clouded with red color, diffused or localized. While in a sense this terminal suffusion is an extension of the characteristic color of the spire, the two red areas are not directly continuous, for the younger portion of the last whorl as viewed in oral aspect shows only the general corneous-yellow ground-color (fig. 48, plate 12). The inner surface in this order is deeper in color than in the ordinary mitella in almost all of the examples; but the lip is usually white, and only in a small minority is it stained with yellow or yellow-brown.

The shells of the Lonfit colony are quite unique within this group, inasmuch as the younger whorls are lighter in color on the sides toward the apex (figs. 49, 50, plate 12), and hence they simulate the bicolor shells in pattern, although their tints are entirely different.

Returning to Tarague, the representatives of this order are much more darkly colored (figs. 51, 52, plate 12). Still more extreme shells were found at Dededo (figs. 53 to 56, plate 12), in which the spire grades from red-brown to purple-brown and the body-whorl is almost entirely suffused with deep colors that usually correspond with those of the upper coils. Yet even in such specimens there are always some areas which lack the overtints. The illustrations show a degree of correspondence between the inner and outer surfaces as regards the depth of color. The outer border of the lip is more frequently stained with brown or orange-brown in the deeply colored shells like those of Dededo. In mitella-rubra, as in the other orders and classes, the white border below the suture varies considerably in width and distinctness.

The adolescent individuals of this order are exactly like those of mitella. This is evident from the fact that no differences can be observed among the members of associations which comprise numerous mitella and mitella-rubra adults, as at Dededo and Tarague. The case of Asados is still more demonstrative, because no adult mitella were taken there, but among the immature individuals are many which are indistinguishable from the adolescents found at the Ylig, where all of the full-grown specimens were mitella. Obviously the two groups in question are intimately related, and are separable only on the basis of differences which arise with the approach to maturity.

The order is represented in the collections from 15 localities, and it is next in total abundance to the related mitella group. Only in the Asados association does it occur without any of its near relatives.

phæa.—Next to the foregoing in abundance is the brown-shelled class to which the distinctive name of phæa is given; it comprises two color-orders, rubra and purpurea, whose differences are indicated by their names.

The Lolo examples of phæa-rubra may be taken as the representatives of their order, because the absence of phæa-purpurea and of mitella-rubra causes them to stand out collectively in sharp contrast with all of their associates. Typically the shell is a rich brown in color (figs. 1 to 3, plate 13), with a certain amount of reddish admixture which produces a ruddy effect when it is abundant (figs. 4, 5, plate 13); the red tints are more pronounced when decortication occurs (figs. 6 to 8, plate 13). Another distinctive feature of this and of the purpurea order of the phæa class is the attenuation of the color on the apical whorls, shown by all specimens to a positive degree, lesser or greater. The inner surface of the shell is more reddened than the outside (figs. 4 to 6, plate 13). There is often some tinge of brown upon the lip (figs. 4, 6, plate 13). The white sutural border varies as in the other classes from narrow and vague (fig. 1, plate 13) to broad and distinct (fig. 8, plate 13); its contrast with the dark ground-colors renders it more conspicuous than in the light mitella and bicolor classes.

The adolescent individuals (figs. 9 to 11, plate 13) exhibit a very light overtone of reddish brown upon the majority of the whorls, at the same time that they display the apical loss of color which is a distinctive feature of the whole phæa class. Like the outer tints, the colors of the inner wall are pale at the outset and become intensified only later in life.

The color-order distinguished as phæa-purpurea comprises equally beautiful shells in which purplish brown takes the place of the ruddy brown of the foregoing (figs. 12 to 23, plate 13). The apex is lighter than the older whorls from early adolescence. There is some difference between the Macajna second and the Asados associations in the average depth of color; shells of the former grade to very dark purple-brown (figs. 13, 14, plate 13); their inner surfaces are likewise relatively deeper in tint (compare figs. 14 and 19, plate 13) and their colors develop earlier in adolescence, both within and without (compare figures 20 and 21 with figures 22 and 23, plate 13). Decortication in this order as in rubra renders the shells more vivid in their coloration (figs. 18, 19, plate 13).

In the matter of their geographical distribution, the phæa shells are most interesting. Nine associations comprise phæa-rubra, and in 5 of these phæa-purpurea is also present but in smaller numbers as the rule. The class is fairly well represented in the 3 localities of the Northeast Region, and in the eastern areas of the adjacent North Central Region; elsewhere it occurs only in the Macajna second collection, and in considerable relative abundance at that place.

The few shells of the illustrations give no idea of the sharp contrast between this class and the others when large series of specimens are examined. Even the phæa adolescent shells are clearly distinguished from those of all other classes, while in addition the differences between the two color-orders within the group are manifested almost from the embryonic period.

castanea.—The primary color-class so denominated resembles phæa in its general brownish tints and in the secondary distinctions of its two constituent orders, but it is none the less separate, and a different name is employed for the sake of description. Its numbers are few, and its members appear sparingly in only 6 of the local collections.

The castanea-rubra order (figs. 24 to 27, plate 13) is well represented by the specimen from Dededo (fig. 24, plate 13), which is ruddy chestnut-brown, without and within. The shells from Macajna second are lighter (figs. 25, 26, plate 13) and the first of these shows the effects of decortication in a more pronounced red color, verging toward pink. In sharp contrast with the phæa shells, the members of this class and order display a *darkened* apex, without exception. And in the immature shells also the apex is distinctly colored, while the rest of the shell displays only a slight but recognizable tinge of the characteristic color which is destined to extend and to intensify with age (fig. 27, plate 13).

In castanea-purpurea purple-brown replaces the ruddy brown of its relative order (figs. 28 to 32, plate 13). All that is said regarding castanea-rubra holds true for this order, allowing for the difference in secondary color-distinction.

It is not possible to confuse the castanea shells with any others, even though some of the darker mitella-rubra seem to approach somewhat near. The differences are always discernible in the adult specimens, while the modes by which the two final phases in question are attained prove to be entirely dissimilar. In like manner the differences between castanea and phæa are equally clear with an abundance of material before one's eyes; and in this case also the two kinds are sharply contrasted in their partly grown stages (compare figs. 11 and 22 with figs. 27 and 32, plate 13).

It is undoubtedly significant that the few localities in which castanea occurs are also populated without exception by the next class, vespera. These two groups are not coextensive, it is true, but the relation of castanea to vespera *in distribution*, and in some respects also in coloration, is closer than to any other class; at first sight the castanea type would seem to be nearer to the mitella-rubra or the phæa class, but the contrary is the case. The castanea localities are not so far separated as their positions in the tabular arrangement would seem to indicate; Macajna, Fonte, and Aniguac are near one another, while Pago north, to the east of the first-named, is not really remote. Dededo is disconnected, it is true, and the presence of castanea at that locality when it is absent from the other collections of the Coast Central Region is an anomaly, due presumably to the small size of the representative series.

vespera.—The *gibba* shells of the present class display the most delicate colors of all, and in recognition of their lesser brilliance, though undiminished beauty, a class name has been chosen which suggests the roseate and lavender tints of the evening horizon.

In the vespera-rosea order, the general ground-color is corneous, overlaid to a lesser or greater extent with rose (figs. 33 to 38, plate 13). The interior is delicate rose-color, and the lip is *always white*. The whorls of the spire, however, are very pale, verging toward whitish-corneous, but the extreme apex is very lightly tinted with pink. When the surface is decorticated (figs. 39 to 42, plate 13) the spire becomes practically white except at the very tip, and the body-whorl changes to a light rose-pink. The immature shells of this type are corneous at first (fig. 43, plate 13) and gain the pink color as a faint suffusion only later (fig. 44, plate 13). The first adolescent illustrated is from Macajna second and it can not be anything but a vespera individual, because unicolor and bicolor are both absent from that locality and because the young of the hooded mitella or of the deeply colored phæa are distinguishable as such by the time they attain the equivalent size.

The related vespera-cyanea shells are similar in their pattern, but they display lavender or lilac shades where rosea is pink (figs. 34 to 51, plate 13). The interior wall is similar to the outer wall in color; the lip is invariably pure shining white.

The adolescents, such as the one from Pago north (fig. 51, plate 13), are very delicately colored with the same attenuation of the colors upon the upper whorls; the specimen in question is entirely different from the **mitella** and **castanea** young of its locality.

Apparently the Barrigarda area is the headquarters of this class, for in that locality the **vespera-rosea** individuals are absolutely abundant and they also far outnumber the other classes taken together. It is not strange that the same type should be well represented at Lolo, but the absence of **vespera** from the Northeast Region is worthy of remark. Elsewhere this class closely coincides with **castanea** in its distribution; there are only slight differences between these two classes in the early stages, and it is with the approach to maturity that the shells of the distinctive adult types diverge more widely.

marginata.—The last class is remarkable on account of its exceptional features of coloration and also because it was found in a single sharply restricted area of bush only a half mile in length at Dungcas. The shells display a corneous color as a basis upon which brownish streaks run transversely (figs. 52 to 56, plate 13); *this is the only color-class in which such strigations occur.* The whorls of the spire are margined along their lower borders with a peculiar rose-brown, and the same color more intensely tinges the outer half of the flaring lip; the distinctive name for the class is chosen on account of these features. In a decorticated individual (fig. 55, plate 13) the streaks and the colored band are less pronounced. The immature specimens (fig. 56, plate 13) prove that the differential characteristics of this class are developed before maturity.

Undoubtedly this is the kind described by Pilsbry on page 316 of the *Manual of Conchology* (volume 20) and illustrated in figure 18, plate 39, of that publication; the shell in question is an old one in which the red component has faded so as to make the brown more evident. Except that it is a member of the same species, *gibba*, it is in no way related to the bicolored shells which served Pease as the types of his variety, for the immature and the embryonic conditions are entirely different. The identification stated is based upon the characteristic strigations which have not been found in any other variety of *gibba*.

This class stands by itself and its genetic derivation is problematical. If the immature coloration gives the clue to its origin it would be placed near **vespera-rosea**, whose adolescents are the most similar. Its close restriction to a small area of thicket east of Agaña and only a few score yards within the strand are the notable features of its geographical location.

A brief general review of the foregoing detailed account of the color-classes will be profitable. The first salient fact is that **mitella** is the dominant form at the present time, for it is the most widespread and the most abundant; furthermore, this type figures prominently in the literature of the past century. However, without additional reasons it is not justifiable to regard the **mitella** coloration as the original type from which all the others have arisen by mutation; there is nothing in the observed facts to indicate which of the existing modes is ancestral with reference to any other. It is conceivable that mitella is itself a recent product which has gained ascendancy over its parental type and its other associates. But whatever the situation in remote centuries, the fact remains that it is of long standing, for it occurs also in Saipan and in Tinian; the view that it has been evolved independently in these separated islands is less tenable than the conclusion that it is an ancient form, possibly distributed by passive colonization but more probably isolated in the several islands by the subsidence of a larger land-mass of earlier epochs on which it ranged widely.

The mitella-rubra order is one which might have arisen independently from mitella in different localities, because its members are not everywhere identical in detail. The Lonfit and the Tarague representatives are especially noteworthy in this connection.

Among the darkly colored classes, the phaea group is abundant in the north as compared with other areas. There are two tenable hypotheses regarding its present condition: firstly, that it originated somewhere in the north and subsequently spread to the other areas now occupied, or secondly, it may have been far more general in its occurrence at an earlier time, only to disappear from much of its original territory. The same problem arises in connection with castanea, but in this case the latter hypothesis is supported by the fact that in Saipan there are types that are undoubted relatives of the castanea of Guam, even though they differ in distinctive details.

With vespera the case is different. This is purely a Guam color-class so far as the facts are known. The present distribution is compact and indicates a center of origin and dispersal focusing about Mount Barrigarda, from which the lines of migration radiate along areas of thicket and forest which are relatively uninterrupted. The relation of vespera to castanea is closer than that of vespera to any other form, as the immature stages demonstrate; whether or not the former was locally produced from the latter by mutation is impossible to determine with absolute certainty, but such an origin is at least probable.

It is interesting to find the ruddy and purplish phases in the three distinct classes, phaea, castanea, and vespera. The same modes are displayed by many another species of *Partula*, such as *P. rosea* of Huaheine and *P. hebe* of Raiatea in the Society Islands. Apparently the two characteristic tints readily replace each other, or are interconvertible by the operation of a minor genetic factor.

The present section must not conclude without reference to the clear demonstration afforded by the foregoing facts that the environmental conditions are wholly devoid of any causative value as regards the qualities of coloration. We can not say that the general occurrence of the mitella type is due to external factors which are identical wherever the class occurs, and at the same time hold such assumed influences responsible for the diverse types of the same areas—that is, identical factors can not be the causes of different results in the way of coloration. Conversely, such ecological diversities as are exhibited by areas like Barrigarda, Macajna second, and Aniguac could scarcely be the reasons for the existence in these places of one and the same color-class like vespera. Again the conditions at Dungcas are exactly like those of Aniguac, yet marginata occurs only at the former place. All of the facts at hand indicate that the internal genetic factors are responsible for the color-characters of *gibba* as well as of other species; the variations in ecological conditions throughout the island determine only the presence or absence of any snails whatsoever, and they exert no qualitative effects that can be discovered.

TABLE 30.—*Partula gibba, Guam. Northeast Region.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
MEAN VALUE.								
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Tarague:								
unicolor	80	17.1395±.0529	11.9175±.0389	69.9500±.1816	9.6700±.0295	7.2450±.0217	74.8125±.1629	56.6375±.1166
bicolor	82	17.1500±.0588	11.9341±.0402	69.5609±.1695	9.7488±.0285	7.2854±.0249	74.6951±.1349	56.7073±.1071
mitella	101	17.1500±.0430	11.9376±.0360	69.4307±.1572	9.7851±.0248	7.2624±.0179	74.0644±.1503	56.9257±.0941
mitella-rubra	19	16.5816±.1628	11.6053±.1271	69.9737±.1835	9.5316±.0690	7.1421±.0590	74.8158±.2659	57.2894±.2385
phæa	9	17.6833±.2353	12.0778±.1779	68.1667±.3671	9.8555±.1386	7.3444±.1055	73.7222±.4341	55.9445±.3018
All	291	17.1005±.0303	11.9137±.0226	69.6065±.0906	9.7289±.0158	7.2588±.0122	74.4863±.0828	56.7784±.0585
Santa Rosa:								
bicolor	1	16.2500	11.7000	71.5000	9.7000	7.5000	76.5000	59.5000
mitella	24	17.0125±.0826	11.4000±.0617	69.4167±.2972	9.6833±.0532	7.1000±.0389	73.5833±.2808	56.4583±.1798
phæa-rubra	43	17.1081±.0526	11.8488±.0435	69.1977±.1577	9.6023±.0302	7.1558±.0308	74.1977±.2179	55.8954±.1352
phæa-purpurea	1	17.1500	11.7000	67.5000	9.3000	7.1000	75.5000	54.5000
All	69	17.0630±.0445	11.8449±.0346	69.2826±.1455	9.6014±.0242	7.1406±.0239	74.0362±.1713	56.1232±.1132
Asados:								
bicolor	4	17.4500±.0	12.0000±.1118	68.5000±.6309	10.0000±.0584	7.4000±.0337	73.5000±.3372	57.2500±.4988
mitella-rubra	65	17.3941±.0504	11.9492±.0425	67.6077±.2055	9.6877±.0307	7.2169±.0303	74.3154±.2095	55.5154±.1232
phæa-rubra	34	17.2559±.0672	12.0059±.0499	69.7059±.3005	9.6471±.0314	7.1647±.0311	74.0882±.2332	55.8529±.1312
phæa-purpurea	37	16.8743±.0591	11.7865±.0501	69.7432±.2178	9.4892±.0357	6.9811±.0355	73.3649±.2081	56.0405±.1278
All	140	17.2250±.0348	11.9214±.0273	69.1715±.1382	9.6343±.0197	7.1472±.0195	73.9857±.1277	55.7857±.0774
STANDARD DEVIATION.								
Tarague:								
unicolor	80	0.7019±.0374	0.5159±.0275	2.4078±.1284	0.3913±.0208	0.2880±.0153	2.1598±.1152	1.5471±.0824
bicolor	82	.7896±.0416	.5399±.0284	2.2758±.1198	.3832±.0201	.3287±.0176	1.8108±.0954	1.4376±.0757
mitella	101	.6416±.0304	.5367±.0254	2.3431±.1111	.3695±.0175	.2666±.0216	2.2401±.1063	1.4026±.0665
mitella-rubra	19	1.0523±.1151	.8217±.0899	1.1862±.1297	.4461±.0488	.3816±.0417	1.7183±.1880	1.5417±.1686
phæa	9	1.0467±.1664	.7913±.1258	1.6329±.2596	.6166±.0980	.4693±.0746	1.9309±.3069	1.3426±.2134
All	291	.7666±.0214	.5711±.0160	2.2912±.0640	.4010±.0112	.3092±.0086	2.0939±.0585	1.4788±.0413
Santa Rosa:								
bicolor	1	...	...	...	...	...	...	...
mitella	24	.5999±.0584	.4481±.0436	2.1586±.2101	.3869±.0376	.2828±.0275	2.0395±.1986	1.3064±.1271
phæa-rubra	43	.5118±.0372	.4228±.0307	1.5331±.1115	.2937±.0213	.2998±.0218	2.1189±.1541	1.3143±.0956
phæa-purpurea	1	...	...	...	...	...	...	...
All	69	.5479±.0314	.4265±.0244	1.7926±.1029	.2981±.0171	.2940±.0619	2.1099±.1211	1.3946±.0800
Asados:								
bicolor	4	.0	.3316±.0790	1.8708±.4461	.1732±.0413	.1000±.0238	1.0000±.2384	1.4790±.3527
mitella-rubra	65	.6023±.0356	.5084±.0300	2.4565±.1453	.3677±.0217	.3627±.0214	2.5047±.1481	1.4728±.0871
phæa-rubra	34	.5815±.0475	.4318±.0353	2.5982±.2125	.2714±.0222	.2688±.0220	2.0164±.1649	1.1346±.0928
phæa-purpurea	37	.5329±.0418	.4521±.0354	1.9646±.1540	.3219±.0252	.3203±.0251	1.8768±.1471	1.1530±.0903
All	140	.6107±.0246	.4791±.0193	2.4244±.0977	.3459±.0139	.3428±.0138	2.2408±.0903	1.3590±.0547

STATISTICAL CHARACTERS OF THE COLOR-CLASSES.

The final task in the analysis of *Partula gibba* is to review the statistical record of the several color-classes belonging to the several local series throughout the island. Its first purpose is to complete the empirical description of the material, thus to establish a basis for any future studies of like nature. The second object is to discover whether distinctive characters of size or form accompany one or another of the modes of coloration; at the outset it may be stated that no such correlation is disclosed.

Northeast Region.—The three representative collections from this territory are somewhat widely separated geographically, and hence it is not surprising that they should differ in color composition as they do. Taragué is one of the two places where unicolor was found; the close relative bicolor appears in all three localities, but with only one example at Santa Rosa. While mitella-rubra and phaea exist in all, it is strange that the more basic type of mitella is absent from Asados.

TABLE 31.—*Partula gibba, Guam. Northeast Region.*

Series.		No.	Lip.			Tooth.		
			White.	Faint yellowish.	Yellowish.	None.	Trace.	Small.
Taragué:	unicolor	80	66	7	7	80	....	....
	bicolor	82	17	12	53	82	....	....
	mitella	102	48	19	35	99	2	1
	mitella-rubra	19	19	....	....	17	2	....
	phæa	9	7	2	....	9	....	....
	All	292	157	40	95	287	4	1
Santa Rosa:	bicolor	1	1	....	....	1	....	....
	mitella	25	6	4	15	15	7	3
	phæa-rubra	45	32	13	....	33	12	....
	phæa-purpurea	1	1	....	....	....	....	1
	All	72	40	17	15	49	19	4
Asados:	bicolor	4	....	....	4	3	....	1
	mitella-rubra	65	62	2	1	31	17	17
	phæa-rubra	34	14	13	7	20	9	5
	phæa-purpurea	37	17	11	9	23	11	3
	All	140	93	26	21	77	37	26

Taking first the Taragué series, the notable points disclosed by the statistics (table 30) are the consistent agreement of unicolor and bicolor, the smaller absolute measures of the mitella-rubra class, and the larger dimensions of the phæa group; the last named is quite as aberrant in proportionate characters as it is in the direct measures. In relation to the color of the lip (table 31) the important point is that the yellowish or yellowish-brown tinge is exhibited mainly by bicolor and mitella shells. As in the former there is some correlation between the depth of color of the revolving bands and the degree to which the lip is stained, it would be expected that in the clouded mitella-rubra shells the lip would be more frequently tinged than in the simpler mitella, but the fact is that the lip is universally white in mitella-rubra. The deeply-placed callus or tooth is very rarely developed in shells of this association.

The Santa Rosa colony is made up principally of mitella and the sharply contrasted phæa-rubra class; its difference from the Tarague series must be real, and not due solely to the fact that smaller collections were secured here. The statistics of record (table 30) show wide departures on the part of the solitary bicolor and phæa-purpurea shells, but the figures are not outside of the ranges within which the other classes vary. The statistics of lip-color and tooth-development (table 31) are self-sufficient.

The notable features of the Asados collection are the absence of mitella, the abundant occurrence of mitella-rubra, and the substantial equivalence of the two color-orders of phæa. The statistics of table 30 show that the bicolor shells are extraordinarily consistent in their absolute measures, but they are highly variable in their proportions The two phæa orders are sensibly the same in shell proportions, although they differ greatly in absolute measures, while in the characters of

TABLE 32.—*Partula gibba, Guam. East Central Region.*

Series.	No.	Mean Value. Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Lolo:								
unicolor	70	16.5671±.0471	11.4371±.0425	69.0000±.1582	9.4314±.0283	6.8143±.0220	73.0143±.1440	56.8143±.110
mitella	47	16.3713±.0579	11.4872±.0424	69.9468±.1731	9.3681±.0333	6.8532±.0251	73.0957±.1473	57.0319±.112
phæa-rubra	55	16.3427±.0538	11.3291±.0492	69.1182±.1839	9.2564±.0309	6.7618±.0261	72.9364±.1652	56.5909±.120
vespera-rosea	50	16.4900±.0635	11.3160±.0564	68.6800±.2172	9.3400±.0366	6.7880±.0288	72.3600±.1779	56.5400±.141
All	222	16.4527±.0277	11.3937±.0241	69.1576=.0932	9.3540±.0163	6.8279±.0131	72.8648±.0804	56.7432±.061
Barrigarda:								
mitella	33	17.0773±.0548	11.9848±.0631	70.1363±.2345	9.8939±.0329	7.2151±.0327	72.8333±.2156	57.8333±.137
mitella-rubra	12	16.9500±.0766	12.0000±.0539	70.6667±.2956	9.7833±.0434	7.1667±.0290	73.2500±.3566	57.6667±.236
phæa-rubra	29	16.8190±.0833	11.5966±.0508	68.9138±.2314	9.8241±.0471	7.3206±.0344	74.0862±.1960	58.1552±.211
vespera-rosea	108	16.8028±.0389	11.6722±.0339	69.3889±.1340	9.6130±.0264	7.0445±.0196	73.2223±.1233	57.0463±.107
All	182	16.8648±.0295	11.7385±.0258	69.5330±.1021	9.7088±.0195	7.1275±.0153	73.2912±.0936	57.4066±.081
Ukudu:								
mitella	53	17.6368±.0657	12.0962±.0468	68.7264±.2624	9.9566±.0362	7.2585±.0237	72.9151±.2079	56.1981±.128
mitella-rubra	17	17.2030±.0999	11.8059±.0582	68.9117±.3274	9.7472±.0442	7.1353±.0322	73.4412±.2728	56.3824±.243
phæa-rubra	1	20.1500	13.5000	67.5000	11.3000	8.3000	73.5000	56.5000
All	71	17.5684±.0617	12.0465±.0413	68.7535±.2114	9.9253±.0327	7.2437±.0222	73.0493±.1693	56.2465±.112
Dededo:								
mitella	43	17.4291±.0660	12.1837±.0589	69.9186±.2512	9.9279±.0378	7.3465±.0331	73.8256±.1930	56.8721±.160
mitella-rubra	47	17.3926±.0526	12.1894±.0498	70.3936±.2001	9.9170±.0339	7.3170±.0322	73.8611±.1982	56.8829±.135
castanea-rubra	2	17.3900±.2847	12.5000±.0	74.5000±.0	10.0000±.0477	7.5000±.0	76.0000±.2384	59.0000±.238
phæa	6	17.4000±.1990	12.2600±.1665	70.0000±.5449	10.0333±.0998	7.4333±.0998	74.3333±.5372	57.3333±.432
vespera	4	17.3750±.0839	11.7500±.0997	67.7500±.5528	9.7500±.0559	7.2000±.0754	73.2500±.6476	56.2500±.279
All	102	17.3971±.0392	12.1804±.0360	70.1471±.1552	9.9235±.0234	7.3353±.0216	73.8921±.1310	56.9216±.098
Saucio:								
mitella	6	17.2000±.1110	11.7333±.0865	68.3333±.4027	9.9333±.0494	7.2000±.0527	72.5000±.3179	55.3333±.210
mitella-rubra	3	17.9500±.0550	12.1000±.0636	67.1666±.4857	10.1000±.0636	7.3000±.0636	72.1666±.1836	56.1666±.367
phæa	2	17.6000±.5008	12.3000±.0954	69.5000±1.4308	10.0000±.2384	7.4000±.0477	74.5000±1.4308	56.5000±.0
vespera-rosea	1	18.0500	12.1000	67.5000	10.1000	7.7000	75.5000	56.5000
All	12	17.5250±.1219	11.9500±.0658	68.1667±.3671	10.0000±.0515	7.3000±.0420	73.0000±.3599	57.0000±.186

TABLE 32.—*Partula gibba, Guam. East Central Region*—Continued.

STANDARD DEVIATION.

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Lolo:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
unicolor	70	0.5846±.0333	0.5276±.0300	1.9621±.1118	0.3511±.0200	0.2727±.0155	1.7868±.1018	1.3662±.0778
mitella	47	.5892±.0409	.4315±.0300	1.7599±.1224	.3384±.0235	.2550±.0177	1.4969±.1473	1.1458±.0797
phæa-rubra	55	.5914±.0380	.5413±.0348	2.0225±.1300	.3404±.0218	.2876±.0184	1.8167±.1168	1.3249±.0852
vespera-rosea	50	.6654±.0449	.5917±.0399	2.2776±.1536	.3837±.0259	.3024±.0203	1.8656±.1258	1.4827±.0100
All	222	.6131±.0196	.5324±.0170	2.0599±.0659	.3596±.0115	.2889±.0092	1.7775±.0568	1.3538±.0433
Barrigarda:								
mitella	33	.4673±.0387	.5372±.0446	1.9972±.1648	.2806±.0232	.2786±.0231	1.8368±.1524	1.1721±.0973
mitella-rubra	12	.3937±.0541	.2769±.0381	1.5183±.2090	.2230±.0307	.1491±.0205	1.8314±.2521	1.2133±.1670
phæa-rubra	29	.6654±.0589	.4055±.0359	1.8479±.1636	.3766±.0333	.2747±.0243	1.5651±.1386	1.6872±.1494
vespera-rosea	108	.5989±.0275	.5224±.0240	2.0648±.0947	.4076±.0187	.3029±.0138	1.8995±.0872	1.6632±.0763
All	182	.5869±.0208	.5166±.0182	2.0424±.0722	.3910±.0138	.3058±.0108	1.8724±.0662	1.6264±.0575
Ukubu:								
mitella	53	.7095±.0464	.5058±.0331	2.8327±.1855	.3912±.0256	.2558±.0167	2.2439±.1470	1.3816±.0905
mitella-rubra	17	.6108±.0706	.3572±.0411	2.0017±.2315	.2704±.0312	.1969±.0227	1.6677±.1929	1.4871±.1720
phæa-rubra	1	....	....	....	....	....	....	....
All	71	.7710±.0436	.5167±.0292	2.6416±.1495	.4083±.0231	.2772±.0157	2.1149±.1197	1.4014±.0793
Dededo:								
mitella	43	.6418±.0466	.5726±.0416	2.4422±.1776	.3675±.0267	.3223±.0234	1.8767±.1365	1.5555±.1131
mitella-rubra	47	.5347±.0372	.5068±.0352	2.0341±.1415	.3448±.0240	.3270±.0227	2.0152±.1401	1.3769±.0957
castanea-rubra	2	.5970±.2013	.0	.0	.1000±.0337	.0	0.5000±.1686	0.5000±.1686
phæa	6	.7228±.1407	.6046±.1177	1.9791±.3853	.3590±.0706	.3590±.0706	1.9508±.3798	1.5723±.3061
vespera	4	.2487±.0593	.2958±.0705	1.6393±.3909	.1658±.0395	.2236±.0533	1.9203±.4579	0.8291±.1977
All	102	.5872±.0277	.5396±.0254	2.3248±.1097	.3502±.0165	.3234±.0153	1.9612±.0926	1.4782±.0698
Saucio:								
mitella	6	.4031±.0785	.3144±.0611	1.4625±.2847	.1795±.0349	.1915±.0372	1.1547±.2248	0.7638±.1487
mitella-rubra	3	.1414±.0389	.1633±.0450	1.2472±.3434	.1633±.0450	.1633±.0450	0.4714±.1298	0.9428±.2596
phæa	2	1.0500±.3541	.2000±.0674	3.0000±1.0117	.5000±.1686	.1000±.0337	3.0000±1.0117	0.
vespera-rosea	1	....	....	....	....	....	....	....
All	12	.6260±.0862	.3379±.0465	1.8856±.2596	.2646±.0364	.2160±.0297	1.8484±.2545	0.9574±.1318

the aperture they are even more dissimilar. This association is almost unique in the matter of tooth development (table 31), for this structure is displayed by some representatives in every class. Indeed, in the mitella-rubra group the shells with a small tooth or a trace of one outnumber those devoid of any such growth whatsoever. The colors of the lip are not noteworthy, but are recorded for completeness (table 31).

The comparison of like classes of the three foregoing series is instructive when it is carried out in detail. By way of example, the phæa shells of Asados are collectively longer, wider, and more slender as compared with those of the mitella group of the same locality; the phæa class of Tarague differs from its associated mitella in exactly the same ways. The characters of the aperture do not display the same kind of correspondence, but in the proportionate value of aperture length to shell length, the phæa shells of both colonies show lower average figures than do the mitella.

East Central Region.—All of the localities within this territory except Saucio provided abundant collections, whose color-compositions are recorded in the census table (table 29). The significant facts revealed by the statistics (tables 32 and 33) may be briefly noted.

TABLE 33.—*Partula gibba, Guam. East Central Region.*

Series.		No.	Lip.					Tooth.		
			White.	Yellowish.	Yellowish-brown.	Faint brown.	Faint reddish brown.	None.	Trace.	Small.
Lolo:	unicolor	70	70	....	....	....	....	30	34	6
	mitella	47	36	8	3	....	....	20	24	3
	phaea-rubra	56	20	....	....	36	....	34	20	2
	vespera-rosea	51	51	....	....	....	....	16	30	5
	All	224	177	8	3	36	....	100	108	16
Barrigarda:	mitella	34	14	8	12	....	....	29	5	....
	mitella-rubra	13	7	4	2	....	....	12	1	....
	phaea-rubra	29	4	18	5	....	2	28	1	....
	vespera-rosea	111	111	....	....	....	....	101	8	2
	All	187	136	30	19	....	2	170	15	2
Ukudu:	mitella	55	7	20	28	....	....	31	13	11
	mitella-rubra	17	12	1	4	....	....	6	6	5
	phaea-rubra	1	....	1	....	....	....	....	1	....
	All	73	19	22	32	....	....	37	20	16
Dededo:	mitella	43	32	7	4	....	....	39	4	....
	mitella-rubra	47	40	2	....	....	5	43	4	....
	castanea-rubra	2	2	....	....	....	....	2	....	....
	phaea-rubra	3	3	....	....	....	....	3	....	....
	phaea-purpurea	3	3	....	....	....	....	3	....	....
	vespera-rosea	2	2	....	....	....	....	2	....	....
	vespera-cyanea	2	2	....	....	....	....	2	....	....
	All	102	84	9	4	....	5	94	8	....
Saucio:	mitella	6	4	2	....	....	....	5	1	....
	mitella-rubra	3	2	....	....	....	1	1	2	....
	phaea-rubra	1	....	1	....	....	....	1	....	....
	phaea-purpurea	1	....	1	....	....	....	1	....	....
	vespera-rosea	1	1	....	....	....	....	1	....	....
	All	12	7	4	....	....	1	9	3	....

The strange unicolor class agrees remarkably with its associates, and gives no evidence of a size differentiation as an accompaniment of its distinctive coloration. The vespera-rosea of Lolo and Barrigarda conform fairly closely to the general conditions of their colonies taken as wholes; if at Barrigarda the shells of this class were noticeably different from their associates, then we might expect the same kind of departures in the average characters of the Lolo representatives if the latter were recent immigrants from the first-named locality. But such an episode, if indeed it actually occurred, must have been so remote as to permit the newly arrived type to amalgamate completely with others at Lolo, so far as the dimensions and proportions of the shells are concerned.

TABLE 34.—*Partula gibba, Guam. South Central Region (in part).*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
MEAN VALUE.								
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Ylig upper:								
mitella	120	16.8300±.0366	11.8733±.0306	70.4750±.1319	9.7150±.0229	7.1250±.0175	73.2750±.1076	57.6167±.0868
Pago north								
mitella	31	17.2661±.0707	12.1459±.0653	70.3710±.2979	9.9129±.0412	7.3774±.0352	74.4352±.2852	57.3065±.1390
mitella-rubra	13	17.6577±.1193	12.2539±.0941	69.3462±.3100	10.1154±.0577	7.2539±.0532	71.8846±.4555	56.9616±.2707
castanea-purpurea	12	17.3000±.0923	12.2000±.1012	70.8333±.3309	10.0167±.0561	7.3666±.0430	73.4167±.2690	57.9166±.3125
vespera-rosea	1	18.6500	13.5000	72.5000	10.9000	8.3000	74.5000	58.5000
vespera-cyanea	14	17.4714±.1011	12.2857±.0616	70.3572±.4301	10.0572±.0513	7.4857±.0461	74.3571±.4192	57.5000±.3122
All	71	17.4035±.0486	12.2211±.0415	70.8887±.1797	10.0099±.0272	7.3873±.0240	73.7958±.1939	57.4014±.1157
Lonfit:								
mitella-rubra	15	18.4300±.0750	12.3933±.0438	66.9667±.2688	10.2467±.0347	7.3667±.0208	71.8333±.2434	55.3000±.1929
Ordot:								
bicolor	8	17.2250±.0996	12.3000±.0859	71.2500±.2859	9.9250±.0442	7.1750±.0409	72.1250±.3759	57.5000±.3145
mitella	21	17.1643±.0701	11.9191±.0559	69.5000±.2171	9.6810±.0384	7.1476±.0255	73.6428±.2238	56.3572±.1384
All	29	17.1810±.0578	12.0241±.0515	69.9827±.2058	9.7483±.0333	7.1552±.0217	73.2249±.2103	56.6734±.1473
STANDARD DEVIATION.								
Ylig upper:								
mitella	120	0.5946±.0259	0.4966±.0216	2.1427±.0932	0.3716±.0162	0.2847±.0124	1.7486±.0761	1.4094±.0614
Pago north:								
mitella	31	.5837±.0500	.5395±.0462	2.4592±.2106	.3405±.0291	.2904±.0249	2.3547±.2016	1.1478±.0983
mitella-rubra	13	.6379±.0843	.5032±.0665	1.6570±.2192	.3084±.0408	.2845±.0376	2.4349±.3221	1.4473±.1914
castanea-purpurea	12	.4743±.0652	.5196±.0715	1.6997±.2340	.2882±.0396	.2211±.0304	1.3819±.1902	1.6051±.2210
vespera-rosea	1	....	....	....	....	....	....	....
vespera-cyanea	14	.5608±.0715	.3420±.0435	2.3862±.3041	.2846±.0363	.2560±.0326	2.3255±.2964	1.7320±.2207
All	71	.6076±.0344	.5184±.0293	2.2449±.1270	.3403±.0192	.2997±.0170	2.4229±.1371	1.4453±.0818
Lonfit:								
mitella-rubra	15	.4308±.0530	.2516±.0310	1.5434±.1901	.1996±.0245	.1193±.0147	1.3980±.1721	1.1075±.1364
Ordot:								
bicolor	8	.4176±.0704	.3605±.0607	1.1989±.2021	.1854±.0312	.1714±.0289	1.5762±.2658	1.3229±.2224
mitella	21	.4764±.0495	.3800±.0395	1.4752±.1535	.2611±.0271	.1735±.0180	1.5208±.1582	0.9404±.0978
All	29	.4617±.0409	.4116±.0364	1.6436±.1455	.2660±.0235	.1733±.0153	1.6795±.1487	1.1763±.1041

The classes of castanea and phæa are too scanty to afford significant facts. It is not surprising that they show distinct departures from the general colonial averages, considering their small representation.

So far as the colors of the lip are concerned (table 33) the only noteworthy point is that in vespera this structure is uniformly white, as everywhere else in the class. The tooth (table 33) reaches its highest general development in the Lolo colony.

South Central Region.—The localities of this territory are numerous, although the collections are not large in all of them. The variations in color-composition are wide, and are undoubtedly accentuated by the uneven and inadequate numbers from several places.

TABLE 35.—*Partula gibba, Guam. South Central Region (in part).*

Series.		No.	Lip.			Tooth.		
			White.	Yellow; yellow-brown.	Brown-orange.	None.	Trace.	Small.
Ylig, upper:	mitella	120	30	34	56	91	29	....
Pago north:	mitella	31	4	24	3	23	7	1
	mitella-rubra	13	9	2	2	12	1	....
	castanea-purpurea	12	2	....	10	11	1	....
	vespera-rosea	1	1	....	....	....	....	1
	vespera-cyanea	14	14	....	....	12	2	....
	All	71	30	26	15	58	11	2
Lonfit:	mitella-rubra	17	1	....	16	17	....	....
Ordot:	bicolor	8	....	8	....	8	....	....
	mitella	21	7	14	....	20	1	....
	All	29	7	22	....	28	1	....

The northern Pago association (table 34) is quite complex, and yet its components agree fairly closely in their statistical characters, except in the case of the single vespera-rosea (fig. 42, plate 13) which is extraordinarily large; another exception is found in the proportions of the aperture of the mitella-rubra class, where the figure is unusually low.

TABLE 36.—*Partula gibba, Guam. South Central Region (cont.), Macajna second.*

Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
MEAN VALUE.								
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
mitella	74	16.8176±.0506	11.7811±.0401	70.0405±.1877	9.6162±.0293	7.0487±.0230	73.2568±.1540	57.0270±.1180
mitella-rubra	21	16.3929±.1177	11.5191±.0832	70.3095±.2012	9.5571±.0636	6.9286±.0429	72.8333±.2375	58.1190±.2055
phæa-rubra	16	16.6438±.1196	11.6625±.0655	70.0000±.3265	9.5375±.0574	7.0750±.0411	74.0000±.2981	57.3125±.2401
phæa-purpurea	7	16.7643±.1905	11.7857±.1538	70.0714±.6505	9.6143±.1085	7.1000±.0817	74.2143±.2959	57.2143±.3785
castanea-rubra	3	16.9500±.1457	11.4333±.1943	67.8333±.4857	9.6333±.0971	7.0333±.1600	72.1666±1.1132	57.5000±.5781
castanea-purpurea	4	17.2250±.0839	12.0500±.1678	69.5000±.9236	9.7500±.0559	7.5000±.1012	73.5000±.8389	56.2500±.2796
vespera-rosea	8	16.3250±.0996	11.3500±.0664	69.5000±.3372	9.3750±.0751	6.9000±.0584	73.7500±.2839	57.2500±.3909
vespera-cyanea	1	16.8500	12.7000	70.5000	10.3000	7.5000	70.5000	56.5000
All	134	16.7224±.0407	11.7075±.0307	69.9891±.1272	9.5925±.0224	7.0343±.0174	73.3508±.1131	57.2388±.0889
STANDARD DEVIATION.								
mitella	74	0.6460±.0358	0.5114±.0283	2.3948±.1327	0.3735±.0207	0.2942±.0162	1.9646±.1089	1.5057±.0834
mitella-rubra	21	.7998±.0832	.5654±.0588	1.3669±.1422	.4457±.0464	.2914±.0303	1.6135±.1608	1.3965±.1453
phæa-rubra	16	.7093±.0845	.3887±.0463	1.9365±.2309	.3407±.0406	.2437±.0290	1.7678±.2108	1.4238±.1698
phæa-purpurea	7	.7472±.1347	.6034±.1087	2.5516±.4600	.4257±.0767	.3207±.0578	1.1606±.2092	1.4846±.2676
castanea-rubra	3	.3741±.1030	.4989±.1374	1.2472±.3434	.2494±.0679	.4109±.1131	3.8586±.7871	1.4142±.4088
castanea-purpurea	4	.2488±.0593	.4975±.1186	2.7386±.6531	.1658±.0395	.3000±.0715	2.4875±.5932	0.8291±.1977
vespera-rosea	8	.4176±.0704	.2784±.0469	1.4142±.2384	.3152±.0531	.2449±.0413	1.1989±.2021	1.6393±.2764
vespera-cyanea	1	....	....	....	....	....	....	....
All	134	.6992±.0288	.5277±.0217	2.1836±.0899	.3845±.0158	.2990±.0123	1.9413±.0800	1.5255±.0628

The Lonfit shells are collectively the largest and the slenderest of all of the colonial series—a fact duly pointed out in the section dealing with intercolonial comparisons. The bicolor, which reappear at Ordot, are too few to justify the seemingly natural deduction that their aberrant measurements indicate a real differentiation from their associated mitella class. The statistics of lip-color and of tooth development (table 35) require no comment.

From the full and interesting statistics of the Macajna second collection (table 36) it appears that, in contrast with the Pago north comparison, mitella-rubra differs from the mitella class in opposite ways so far as the absolute measures of the shells are concerned, but to insignificant degrees in the matter of proportions. The aperture characters do not exhibit the same relations; in mitella-rubra of Pago north this feature is longer, narrower, and far more slender than in mitella of the same place, while at Macajna second it is shorter, narrower, and slightly more slender in the first-named group. Without multiplying the citations, it is certain that no consistent differences in measures accompany one or another of the distinctive modes of coloration; all classes seem to intermingle so far as statistical qualities are concerned. A detail of interest is that the purplish color-orders run rather larger than their ruddy counterparts in all of the darker classes, but the differences are not statistically significant in all cases, and an exception need not be entered. The lip in castanea shells (table 37) sometimes shows a slight tinge of the brownish color of the body-whorls. The tooth (table 37) is weakly developed.

TABLE 37.—*Partula gibba, Guam. South Central Region (cont.), Macajna second.*

Series.	No.	Lip.					Tooth.		
		White.	Yellowish.	Brown; brown-orange.	Rosy.	Purplish.	None.	Trace.	Small.
mitella	76	17	11	48	....	....	64	12	....
mitella-rubra	22	13	2	7	....	....	22	....	....
phæa-rubra	18	12	4	2	....	....	16	2	....
phæa-purpurea	7	3	....	4	....	....	7	....	....
castanea-rubra	3	....	....	1	2	....	3	....	....
castanea-purpurea	4	....	....	1	....	3	4	....	....
vespera-rosea	8	8	....	....	....	....	6	2	....
vespera-cyanea	1	1	....	....	....	....	1	....	....
All	139	54	17	63	2	3	123	16	....

The data for the remaining collections from the South Central Region are given in tables 38 and 39; in principle they confirm the conclusions drawn from similar facts in foregoing sections.

Coast Central Region.—Only in the case of Aniguac are the numbers satisfactorily ample; at numerous places within this territory collections were made, often in passing, mainly to discover what types were present. The statistics (tables 40 and 41) provide additional material for detailed comparisons like those made earlier.

The unique marginata class of Dungcas does not differ substantially from its associates in its measurable qualities. This is important, because it proves that

TABLE 38.—*Partula gibba, Guam. South Central Region (cont.).*

Series.	No.	Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
MEAN VALUE.								
Macajna first:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
mitella	10	17.3000±.1380	12.0200±.1048	69.5000±.3815	9.8400±.0787	7.3600±.0541	74.5000±.3694	57.0000±.2384
mitella-rubra	6	17.5500±.1558	12.0000±.1088	68.6667±.3341	9.9333±.0558	7.4333±.0410	74.6666±.4878	56.8333±.3044
All	16	17.3933±.1093	12.0125±.0756	69.1875±.2778	9.8750±.0544	7.3875±.0376	74.5625±.2949	56.9375±.1882
Fonte A:								
bicolor	10	17.3000±.1080	11.7400±.0870	66.9000±.2175	9.8200±.0578	7.0200±.0578	71.3000±.4013	56.3000±.1596
mitella	137	17.1631±.0373	11.7876±.0270	68.5803±.0957	9.7686±.0203	7.0197±.0161	71.8212±.1034	56.7336±.0686
mitella-rubra	31	17.2855±.0651	11.9322±.0465	69.0484±.1966	9.8097±.0336	7.0419±.0309	71.8871±.1986	56.6290±.1296
castanea-purpurea	15	17.0300±.1218	11.8200±.0739	69.3666±.2905	9.8600±.0754	7.1000±.0539	72.0333±.2190	57.6333±.2190
vespera-rosea	2	17.1500±.0	11.8000±.0477	69.0000±.7154	9.8000±.0477	7.1000±.0954	72.0000±.2384	57.5000±.4769
vespera-cyanea	7	16.9357±.1514	11.7286±.1232	69.2143±.2626	9.7572±.0706	6.9857±.0977	71.7857±.5571	57.2143±.1784
All	202	17.1707±.0298	11.8084±.0214	68.6527±.0795	9.7847±.0162	7.0291±.0134	71.8202±.0831	56.7857±.0558
Fonte B:								
bicolor	2	17.1500±.2862	11.9000±.2862	68.5000±.4769	10.1000±.1908	7.3000±.1908	72.0000±.7154	58.5000±.0
mitella	57	16.6342±.0591	11.0193±.0410	66.1842±.1764	9.4158±.0267	6.6684±.0245	70.5175±.1375	56.5526±.1164
castanea-purpurea	7	16.8500±.1156	11.3571±.1240	67.0714±.2303	9.6143±.0764	6.8714±.0635	71.3571±.3455	56.9285±.1261
vespera-cyanea	9	17.0167±.1561	11.8111±.1342	69.2777±.3789	9.7222±.0677	7.0555±.0552	72.0555±.3688	57.0555±.2620
All	75	16.7140±.0519	11.1693±.0440	66.7000±.1656	9.4893±.0266	6.7507±.0247	70.8200±.1275	56.7000±.0986
Asan:								
bicolor	5	17.3900±.0891	11.6600±.0703	66.1000±.1478	9.7400±.0703	6.9000±.0853	70.9000±.4091	55.7000±.2955
mitella	26	16.9885±.0795	11.9154±.0518	68.9231±.1688	9.5000±.0464	6.9615±.0318	73.0384±.2268	55.7693±.1667
mitella-rubra	5	17.3000±.2110	11.6200±.1507	68.1000±.6211	9.5000±.0853	6.9000±.1144	72.5000±.6878	56.7000±.2257
vespera-cyanea	2	17.4500±.1431	11.8000±.0477	66.5000±.4769	10.0000±.1431	7.3000±.0	73.0000±.7154	57.5000±.0
All	38	17.0316±.0646	11.8368±.0438	68.3158±.1848	9.5579±.0385	6.9632±.0284	72.6842±.2068	55.9736±.1346
STANDARD DEVIATION.								
Macajna first:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
mitella	10	0.6469±.0976	0.4915±.0741	1.7888±.2697	0.3693±.0556	0.2538±.0382	1.7320±.2612	1.1180±.1686
mitella-rubra	6	.5657±.1102	.3952±.0769	1.2134±.2362	.2027±.0394	.1491±.0290	1.7717±.3449	1.1055±.2152
All	16	.6482±.0773	.4484±.0534	1.6477±.1964	.3230±.0384	.2233±.0266	1.7488±.2085	1.1163±.1331
Fonte A:								
bicolor	10	.5064±.0763	.4079±.0615	1.0198±.1538	.2713±.0409	.2713±.0409	1.8815±.2837	0.7481±.1128
mitella	137	.6473±.0264	.4697±.0191	1.6613±.0677	.3522±.0143	.2802±.0114	1.7959±.0731	1.1916±.0485
mitella-rubra	31	.5379±.0460	.3839±.0329	1.6232±.1390	.2775±.0237	.2539±.0218	1.6398±.1404	1.0699±.0916
castanea-purpurea	15	.6997±.0861	.4246±.0522	1.6680±.2054	.4333±.0533	.3098±.0381	1.2579±.1548	1.2579±.1548
vespera-rosea	2	.0	.1000±.0337	1.5000±.5058	.1000±.0337	.2000±.0674	0.5000±.1686	1.0000±.3372
vespera-cyanea	7	.5938±.1070	.4832±.0871	1.0301±.1857	.2770±.0499	.3833±.0691	2.1853±.3939	0.6998±.1261
All	202	.6278±.0211	.4519±.0151	1.6761±.0562	.3414±.0114	.2823±.0095	1.7507±.0587	1.1769±.0394
Fonte B:								
bicolor	2	.6000±.2024	.6000±.2024	1.0000±.3372	.4000±.1349	.4000±.1349	1.5000±.5058	0.
mitella	57	.6619±.0418	.4586±.0290	1.9748±.1247	.2996±.0189	.2747±.0173	1.5389±.0972	1.3032±.0823
castanea-purpurea	7	.4535±.0817	.4866±.0877	0.9035±.1628	.2996±.0540	.2491±.0449	1.3553±.2443	0.4949±.0891
vespera-cyanea	9	.6944±.1104	.5971±.0949	1.6852±.2679	.3010±.0479	.2455±.0390	1.6406±.2608	1.1654±.1852
All	75	.6651±.0367	.5643±.0311	2.1229±.1171	.3408±.0188	.3168±.0174	1.6343±.0901	1.2649±.0697
Asan:								
bicolor	5	.2956±.0630	.2332±.0497	0.4899±.1045	.2332±.0497	.2828±.0603	1.3564±.2893	0.9798±.2089
mitella	26	.6013±.0562	.3919±.0366	1.2762±.1193	.3508±.0328	.2403±.0225	1.7148±.1604	1.2575±.1176
mitella-rubra	5	.6997±.1492	.4996±.1065	2.0591±.4392	.2828±.0603	.3794±.0809	2.2803±.4364	0.7483±.1596
vespera-cyanea	2	.3000±.1012	.1000±.0337	1.0000±.3372	.3000±.1012	.0	1.5000±.5058	0.
All	38	.5902±.0457	.4003±.0310	1.6895±.1307	.3521±.0272	.2599±.0201	1.8898±.1462	1.2299±.0952

this color-class is an integral member of the species, and that it is not so distinguished in qualities other than those of coloration as to be accorded the status of a taxonomic variety.

How greatly two neighboring associations may differ is well illustrated by the inner and outer Presidio series. The numbers are sufficient to afford reliable determinations for comparison when the probable errors are taken into account. The two localities are separated only by a roadway and a narrow belt of grassland, yet the shells are collectively quite diverse.

TABLE 39.—*Partula gibba, Guam. South Central Region (cont.).*

Series.		No.	Lip.			Tooth.		
			White.	Yellow; yellow-brown.	Brown-orange; red-brown.	None.	Trace.	Small.
Macajna first:	mitella	10	1	9	....	10	....	....
	mitella-rubra	6	5	1	....	6	....	....
	All	16	6	10	....	16	....	....
Fonte A:	bicolor	10	3	7	....	10	....	....
	mitella	140	59	79	2	136	4	....
	mitella-rubra	31	9	22	....	30	1	....
	castanea-purpurea	15	....	1	14	15	....	....
	vespera-rosea	2	2	....	....	2	....	....
	vespera-cyanea	7	7	....	....	6	1	....
	All	205	80	109	16	199	6	....
Fonte B:	bicolor	2	2	....	....	2	....	....
	mitella	57	5	52	....	57	....	....
	castanea-purpurea	7	4	....	3	7	....	....
	vespera-cyanea	10	10	....	....	10	....	....
	All	76	21	52	3	76	....	....
Asan:	bicolor	5	....	5	....	5	....	....
	mitella	27	9	18	....	25	2	....
	mitella-rubra	5	....	5	....	5	....	....
	vespera-cyanea	2	2	....	....	2	....	....
	All	39	11	28	....	37	2	....

The statistics of lip-color and of tooth development (table 41) record the unique quality of the former in marginata and the slight degrees of the latter in all associations.

Apra, West Central, and Southwest Regions.—The remaining primary regions of the islands are sparsely settled by *gibba*, and indeed the Southeast Region is devoid of the species, judging by the single representative collection from Inarajan. The points of major interest are that mitella alone was found at Orote, that it dominates at Salifan, and that it gives place to bicolor at the extreme southwest. From the statistics (table 42) it appears that the bicolor shells are unusually large with consistency. Some color is shown by the lips of nearly all specimens, and the tooth is generally absent (table 43).

From the foregoing current account and from the statistics upon which this is based, it is apparent that the color-classes of various kinds are not structurally differentiated so as to acquire the distinctness of taxonomic varieties. It is especially important that this is true for the proportionate measures as well as for the direct dimensions, because the statement is made in the literature that bicolor is less gibbous than its associates; variations in shape as well as in size occur almost indifferently in all color-classes.

The general accord which is displayed by the component classes of a highly diversified association such as that of Macajna second or of Lolo indicates the absence of physiological barriers to free intercrossing on the part of such constituents. The statistics of heredity, considered in the next section, strongly support the same conclusion.

TABLE 40.—*Partula gibba, Guam. Coast Central Region.*

Mean Value.								
Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Tumon:								
mitella	2	17.3000±.0715	11.7000±.0477	68.0000±.7154	10.0000±.0477	7.2000±.0477	72.0000±.7154	57.5000±.4769
Oco:								
bicolor	2	17.3000±.0715	11.2000±.0477	64.5000±.0	9.3000±.0954	6.8000±.0477	73.0000±.2384	53.5000±.4769
mitella	7	16.7653±.0788	11.5000±.0545	68.6428±.2123	9.3857±.0938	7.0428±.0591	75.3571±.5689	55.9286±.3568
mitella-rubra	1	16.5500	11.7000	69.5000	9.3000	6.9000	74.5000	55.5000
vespera-rosea	2	16.1000±.0715	11.5000±.0954	71.0000±.2384	9.3000±.0	7.1000±.0	75.5000±.4769	57.5000±.0
vespera-cyanea	2	16.5500±.2861	10.8000±.2384	65.0000±.2384	9.0000±.1431	6.6000±.1431	73.0000±.2384	55.0000±.2384
All	14	16.7000±.0836	11.3714±.0662	67.9286±.4072	9.3000±.0578	6.9428±.0475	74.6428±.3531	55.6428±.2797
Timoneng:								
bicolor	4	16.3250±.2661	11.3500±.1277	69.5000±.3894	9.3500±.0645	6.8500±.0645	73.2500±.5761	57.2500±.3228
mitella	7	16.4643±.0977	11.6143±.0600	70.3571±.2868	9.6428±.0525	7.2714±.0504	75.3571±.4184	58.5000±.4309
mitella-rubra	4	16.6250±.1728	11.2500±.1390	67.7500±.1686	9.8000±.1404	6.9500±.1152	70.7500±.3228	59.0000±.3372
All	15	16.4700±.0884	11.4467±.0589	69.4333±.2501	9.6066±.0608	7.0733±.0506	73.5667±.4144	58.3000±.2577
Dungcas:								
mitella	26	16.6769±.0796	11.6692±.0604	69.9231±.2962	9.7231±.0442	7.1846±.0313	73.7307±.2414	58.3462±.1586
mitella-rubra	1	16.5500	10.5000	63.5000	9.5000	6.7000	70.5000	56.5000
marginata	6	16.8000±.1383	11.5667±.0936	69.0000±.6698	9.7333±.0740	7.0667±.0205	72.6667±.4612	58.1667±.3784
All	33	16.6954±.0678	11.6151±.0557	69.5606±.2947	9.7182±.0376	7.1485±.0271	73.4394±.2219	58.2576±.1475
Agaña:								
mitella	29	16.9845±.0722	11.9414±.0453	70.4311±.2324	9.6379±.0451	7.2379±.0302	74.8448±.2777	56.7068±.2357
Aniguac:								
bicolor	21	17.0072±.1346	11.7762±.0887	68.8810±.2466	9.4810±.0609	7.0333±.0492	73.7857±.3858	55.7857±.2913
mitella	191	17.1107±.0360	11.8466±.0279	69.1963±.0982	9.8026±.0208	7.1188±.0159	72.4738±.0891	57.2173±.0810
castanea-rubra	2	17.1500±.1431	12.4000±.0477	72.5000±.9539	10.1000±.0954	7.4000±.0477	73.0000±.2384	59.0000±.2384
castanea-purpurea	1	16.2500	11.5000	70.5000	9.7000	6.9000	71.5000	59.5000
vespera-cyanea	4	17.7500±.1012	12.4000±.1216	69.5000±.7909	10.5500±.0997	7.5000±.2861	71.5000±.3372	59.0000±.5058
All	219	17.1089±.0344	11.8534±.0262	69.2078±.0918	9.7877±.0203	7.1192±.0150	72.5822±.0884	57.1393±.0806
Cemetery:								
mitella	38	16.6053±.0793	11.5210±.0602	69.2895±.1947	9.5526±.0516	7.0790±.0375	74.0263±.2494	57.4737±.1748
Presidio inner:								
mitella	62	16.0855±.0461	11.3548±.0339	70.6774±.1354	9.2452±.0254	6.9516±.0201	75.1459±.1444	57.4194±.1035
Presidio outer:								
mitella	30	17.0800±.0686	11.8200±.0499	69.3667±.2597	9.8067±.0322	7.1733±.0301	73.1000±.2147	57.4333±.2441

TABLE 40.—*Partula gibba, Guam. Coast Central Region*—Continued.

STANDARD DEVIATION.								
Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Tumon:								
mitella	2	0.1500±.0505	0.1000±.0337	1.5000±.5058	0.1000±.0337	0.1000±.0337	1.5000±.5058	1.0000±.3372
Oco:								
bicolor	2	.1500±.0505	.1000±.0337	.0	.2000±.0674	.1000±.0337	.5000±.1686	1.0000±.3372
mitella	7	.3090±.0557	.2138±.0385	0.8330±.1501	.3681±.0663	.2321±.0418	2.2316±.4023	1.3997±.2523
mitella-rubra	1	....	....	....	....	....	....	....
vespera-rosea	2	.1500±.0505	.2000±.0674	.5000±.1686	.0	.0	1.0000±.3372	.0
vespera-cyanea	2	.6000±.2023	.5000±.1686	.5000±.1686	.3000±.1012	.3000±.1012	.5000±.1686	.5000±.1686
All	14	.4641±.0591	.3673±.0468	2.2588±.2879	.3207±.0409	.2638±.0336	1.9587±.2497	1.5518±.1978
Timoneng:								
bicolor	4	.6833±.1881	.3279±.0903	1.0000±.2753	.3840±.1057	.1658±.0456	1.4794±.4073	.8291±.2282
mitella	7	.3833±.0691	.2356±.0424	1.1249±.2028	.2060±.0371	.1979±.0356	1.6414±.2958	1.6903±.3047
mitella-rubra	4	.4437±.1222	.3570±.0983	.4330±.1192	.3605±.0993	.2958±.0814	.8291±.2282	.8660±.2384
All	15	.5075±.0625	.3383±.0416	1.4360±.1768	.3492±.0430	.2909±.0358	2.3795±.2930	1.4697±.1822
Dungcas:								
mitella	26	.6018±.0563	.4564±.0427	2.2390±.2094	.3343±.0312	.2365±.0221	.1.8525±.1707	1.1991±.1121
mitella-rubra	1	....	....	....	....	....	....	....
marginata	6	.5025±.0977	.3399±.0662	2.4324±.4737	.2687±.0523	.0745±.0145	1.6749±.3261	1.3744±.2675
All	33	.5774±.0479	.4749±.0394	2.5098±.2084	.3204±.0266	.2311±.0191	1.8899±.1569	1.2560±.1043
Agaña:								
mitella	29	.5767±.0510	.3615±.0320	1.8557±.1643	.3605±.0319	.2413±.0213	2.2171±.1963	1.8824±.1666
Aniguac:								
bicolor	21	.9147±.0952	.6031±.0627	1.6755±.1744	.4136±.0430	.3343±.0348	2.6210±.2728	1.9795±.2060
mitella	191	.7373±.0254	.5718±.0197	2.0135±.0694	.4267±.0147	.3263±.0112	1.8260±.0630	1.6606±.0573
castanea-rubra	2	.3000±.1012	.1000±.0337	2.0000±.6745	.2000±.0674	.1000±.0337	.5000±.1686	0.5000±.1686
castanea-purpurea	1	....	....	....	....	....	....	....
vespera-cyanea	4	.3000±.0715	.3605±.0860	2.3452±.5582	.2958±.0705	.8485±.2023	1.0000±.2384	1.5000±.3576
All	219	.7541±.0243	.5761±.0185	2.0151±.0649	.4450±.0143	.3302±.0106	1.9404±.0625	1.7670±.0570
Cemetery:								
mitella	38	.7246±.0561	.5502±.0425	1.7794±.1377	.4717±.0365	.3427±.0265	2.2796±.1763	1.5975±.1236
Presidio inner:								
mitella	62	.5379±.0326	.3954±.0240	1.5814±.0957	.2966±.0179	.2354±.0142	1.6859±.1021	1.2088±.0732
Presidio outer:								
mitella	30	.5569±.0485	.4053±.0353	2.1092±.1836	.2619±.0227	.2449±.0213	1.7435±.1518	1.9821±.1726

What has been said concerning structural differentiation is equally true for the white sutural border which varies independently of the distinctive modes of coloration. And finally, the degree to which the tooth may be developed varies colonially and not directly in correspondence with a particular color-pattern; the summary in this connection is given in table 44. While it is true that the percentages differ in the several classes, the fact of the matter is that the general absence of a callus in bicolor, for example, is due to the weak development of that structure in the colonies where this coloration is more often displayed. Conversely phæa and mitella-rubra display higher frequencies for the tooth, because their color-patterns are particularly abundant in colonies which also possess the genetic factors for the positive production of the characteristic tooth in a greater number of cases. Hence there is only a false or coincident correlation between a color mode and the degree of tooth development.

TABLE 41.—*Partula gibba, Guam. Coast Central Region.*

Series.		No.	Lip.				Tooth.		
			White.	Yellow; yellow-brown.	Brown; brown-orange.	Pink.	None.	Trace.	Small.
Tumon:	mitella	2	1	....	1	....	2	....	....
Oco:	bicolor	2	1	1	....	....	1	1	....
	mitella	7	7	....	....	....	7	....	....
	mitella-rubra	1	1	....	....	....	1	....	....
	vespera-rosea	2	2	....	....	....	2	....	....
	vespera-cyanea	2	2	....	....	....	1	....	1
	All	14	13	1	....	....	12	1	1
Timoneng:	bicolor	4	....	4	....	....	4	....	....
	mitella	8	....	3	5	....	7	1	....
	mitella-rubra	4	....	....	4	....	4	....	....
	All	16	....	7	9	....	15	1	....
Dungcas:	mitella	28	25	3	....	....	22	6	....
	mitella-rubra	1	....	1	....	....	1	....	....
	marginata	6	....	....	....	6	4	2	....
	All	35	25	4	....	6	27	8	....
Agafia:	mitella	29	3	26	....	....	27	2	....
Aniguac:	bicolor	21	....	21	....	....	21	....	....
	mitella	194	47	147	....	....	189	5	....
	castanea-rubra	2	2	....	....	....	2	....	....
	castanea-purpurea	1	1	....	....	....	1	....	....
	vespera-cyanea	4	4	....	....	....	4	....	....
	All	222	54	168	....	....	217	5	....
Cemetery:	mitella	39	2	37	....	....	38	1	....
Presidio, inner:	mitella	65	3	62	....	....	61	4	....
Presidio, outer:	mitella	33	1	32	....	....	33	....	....

EMBRYONIC MATERIAL.

The statistics relating to the embryonic material are unqualified in their value for the determination of the reproductive rate of the species at the time that field-work was carried on. They are less useful for the problems of heredity, although as regards the question of mutual interbreeding on the part of the several color-classes they give positive results.

No instance of fertility has been observed before the shell is completed by the formation of the flaring lip; it is only because the opposite is true in the case of *P. fragilis* that this statement is formally recorded. Like the egg-capsules of *P. radiolata*, those of *gibba* are clearly transparent and entirely devoid of calcareous impregnations in their walls. They are cask-shaped, ranging in length from 3.5 to 4.5 mm., and in breadth from 3 to 3.5 mm. Still within the brood-pouch and

Table 42.—*Partula gibba, Guam. Apra, West Central, and Southwest Regions.*

Series.	No.	Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
Mean Value.								
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Orote: mitella	19	16.6763±.0644	12.1210±.0687	72.3421±.2573	9.7421±.0433	7.2684±.0417	74.5526±.2432	58.1842±.1813
Agat: mitella	6	16.7000±.1952	11.6667±.0922	69.1667±.5192	9.7000±.1189	7.1000±.0841	72.8333±.4943	57.5000±.3179
Salifan: bicolor	1	17.7500	12.1000	67.5000	10.1000	7.3000	72.5000	56.5000
mitella	85	17.3371±.0510	12.0647±.0342	69.6294±.1298	9.9470±.0290	7.3282±.0224	73.6059±.1299	57.3471±.1037
Umatac Salonga: bicolor	7	17.3643±.1059	11.5572±.0534	66.3572±.4400	9.8429±.0230	7.0429±.0357	71.7857±.4859	56.0714±.2676
Umatac Pajom: bicolor	9	17.7500±.0779	12.3000±.0670	69.2777±.2956	10.0555±.0591	7.4555±.0412	74.1666±.3671	56.5000±.2596
Umatac Madog: bicolor	6	17.6500±.0616	12.0000±.0527	67.8333±.2052	9.8333±.0757	7.2667±.0587	73.8333±.3784	55.3333±.2938
Merizo: bicolor	1	17.4500	12.5000	71.5000	10.1000	7.3000	73.5000	57.5000
Standard Deviation.								
Orote: mitella	19	0.4165±.0455	0.4444±.0486	1.6627±.1819	0.2797±.0306	0.2696±.0295	1.5719±.1719	1.1721±.1282
Agat: mitella	6	.7089±.1380	.3349±.0652	1.8856±.3671	.4320±.0841	.3055±.0594	1.7951±.3495	1.1547±.22448
Salifan: bicolor	1	....	....	....	....	....	....	....
mitella	85	.6979±.0360	.4675±.0242	1.7743±.0918	.3960±.0205	.3070±.0518	1.7758±.0918	1.4148±.0733
Umatac Salonga: bicolor	7	.4155±.0749	.2096±.0377	1.7262±.3111	.0904±.0162	.1400±.0252	1.9059±.3436	1.0498±.1892
Umatac Pajom: bicolor	9	.3464±.0551	.2981±.0474	1.3147±.2090	.2629±.0418	.1833±.0291	1.6329±.256	1.1507±.1835
Umatac Madog: bicolor	6	.2236±.0435	.1915±.0372	.7453±.1451	.2749±.0535	.2134±.0415	1.3744±.2675	1.0673±.2077
Merizo: bicolor	1	....	....	....	....	....	....	....

within the wall of the capsule, the young snail may grow until its shell is 4.5 mm. in length before it is born.

The total number of adults available for the record of embryonic material is 2,384, as only 20 were omitted for various reasons; the statistics of their contents are given in full in table 45. The proportion of gravid individuals in the whole collection is 85.8 per cent, which is almost exactly the same as in the *radiolata* series. As the 2,046 gravid adults yielded 6,053 young and eggs, the reproductive rate of the entire series of *gibba* is sensibly lower than that of *radiolata*, namely, 2.54 as compared with 3.55. This difference might be variously interpreted; it may mean that the breeding seasons of the two species do not coincide, and that *radiolata* was at the height of its activity at the time of investigation, while *gibba* had not fully entered or had recently completed its own cycle of reproduction. Again, it may be that *radiolata* is now developing in greater relative numbers than before, or conversely that the rate in *gibba* is declining. Finally, it is possible that the rate of reproduction, equilibrated in time with reference to eliminative influences so that two species solidly maintain themselves, differs because *radiolata* is more susceptible to decimating conditions and is consequently compelled to multiply at a slightly higher rate. Which of the foregoing suggestions is correct is difficult to determine without making a similar study of fertility at some other time of the year.

TABLE 43.—*Partula gibba, Guam. Apra, West Central, and Southwest Regions.*

Series.		No.	Lip.		Tooth.	
			White.	Yellow; yellow-brown.	None.	Trace.
Orote:	mitella	19	3	16	19	....
Agat:	mitella	6	....	6	6	....
Salifan:	bicolor	1	....	1	1	....
	mitella	85	....	85	76	9
Umatac Salonga:	bicolor	7	....	7	7	....
Umatac Pajom:	bicolor	9	2	7	9	....
Umatac Madog:	bicolor	7	....	7	7	....
Merizo:	bicolor	1	....	1	1	....

Inquiring more closely into the existence of a defined breeding season, we may deal with the problem as in the case of *radiolata*. Using the data given in table 45, correlations may be worked out between the passage of the weeks and the number and nature of the embryonic contents, employing the 24 collections which are sufficiently numerous for the purpose. The result is zero for the correlation between the lapse of time and the percentage of gravid individuals which means that certain snails conclude their reproductive phase as rapidly as others enter it. When the lapse of time and the total contents are correlated, the figure is -0.0230 ± 0.1376; and when the passage of the weeks is correlated with the number of eggs, the result is -0.0600 ± 0.1372. Both coefficients are less than their probable errors and therefore are not intrinsically significant.

TABLE 44.—*Partula gibba, Guam. Statistics of tooth development in the several color-classes.*

Color-class.	Total No.	Number.			Per cent.		
		None.	Trace.	Small.	None.	Trace.	Small.
unicolor	150	110	34	6	73.3	22.7	4.0
bicolor	164	162	1	1	98.8	0.6	0.6
mitella	1,309	1,151	139	19	87.9	10.6	1.4
mitella-rubra	264	208	34	22	78.8	12.9	8.3
phæa	245	178	56	11	72.6	22.8	4.5
castanea	46	45	1	....	97.8	2.2	....
vespera	220	168	43	9	76.4	19.5	4.1
marginata	6	4	2	....	66.6	33.3	....
Summary	2,404	2,026	310	68	84.2	12.9	2.8

However, such results would follow if a definite reproductive period did occur in *gibba* and began earlier than in *radiolata*. Then the total contents would naturally diminish during the period of collection, while furthermore the negative correlation between the number of eggs and the lapse of time would be greater than that between the total contents and the latter datum. It is possible, therefore, that the animals of this species respond even more readily than do those of *radiolata* to the increased temperature and greater humidity of the late spring months. The facts as observed do not demonstrate this as opposed to the possibility that the animals reproduce indifferently throughout the year, and the data are in accord with either hypothesis. But the former conclusion is preferable on general grounds and because it is established in the analogous case of *radiolata*.

TABLE 45.—*Partula gibba, Guam. Statistics of fecundity.*

Locality.	Date (1920.)	Records.	Gravid.		Embryonic contents.			Average for gravid.			Average for all.
			No.	Per cent.	Eggs.	Young.	Total.	Eggs.	Young	Total contents.	
Tarague	Aug. 15	292	222	76.03	260	288	548	1.17	1.30	2.47	1.88
Santa Rosa	July 1	68	66	97.06	134	75	209	2.03	1.14	3.17	3.07
Asados	Aug. 10	140	122	87.14	147	130	277	1.20	1.06	2.27	1.98
Lolo	July 7	218	201	92.20	301	219	520	1.50	1.09	2.59	2.39
Barrigarda	July 19	187	153	81.82	252	142	394	1.65	0.93	2.57	2.11
Dededo	July 2	72	69	95.83	161	97	258	2.33	1.41	3.74	3.58
Ukudu	July 12	102	87	85.29	159	114	273	1.83	1.31	3.14	2.68
Saucio	July 3	12	10	83.33	23	12	35	2.30	1.20	3.50	2.75
Ylig, upper	July 23	120	100	83.33	237	105	342	2.37	1.05	3.42	2.85
Pago, north	July 2	70	59	84.28	124	62	186	2.10	1.05	3.15	2.66
Lonfit	June 30	17	13	76.47	34	19	53	2.61	1.46	4.08	3.12
Ordot	June 29; Aug. 18	27	26	96.29	62	35	97	2.38	1.35	3.73	3.59
Macajna, second	Aug. 14	136	112	82.35	241	124	365	2.15	1.11	3.26	2.68
Macajna, first	July 18	16	15	93.75	35	10	45	2.33	0.67	3.00	2.81
Fonte A	July 6	205	183	89.27	342	199	541	1.87	1.09	2.96	2.64
Fonte B	July 10	75	72	96.00	124	70	194	1.72	0.97	2.69	2.59
Asan	Aug. 8	39	29	74.36	49	25	74	1.69	0.86	2.55	1.90
Tumon	Aug. 23	1	1	[100]	3	1	4	3	1	4	4
Oco	July 24	14	8	57.14	21	5	26	2.62	0.62	3.25	1.86
Timoneng	July 24	16	16	100	35	11	46	2.19	0.69	2.88	2.88
Dungcas	July 8	34	30	88.23	61	43	104	2.03	1.43	3.46	3.06
Agaña	Aug. 19	29	25	86.21	56	33	89	2.24	1.32	3.56	3.07
Aniguac	Aug. 13	222	192	86.48	408	237	645	2.12	1.23	3.36	2.90
Cemetery	Aug. 8	39	37	94.87	89	33	122	2.41	0.89	3.30	3.13
Presidio, inner	Aug. 15	65	60	92.31	110	77	187	1.83	1.28	3.11	2.88
Presidio, outer	Aug. 15, 16, 25	33	28	84.85	70	39	109	2.50	1.39	3.89	3.30
Orote	July 10	19	12	63.16	29	9	38	2.42	0.75	3.17	2.00
Agat	Aug. 22	6	6	100	11	6	17	1.83	1.00	2.83	2.83
Salifan	Aug. 22	86	74	86.05	104	88	192	1.40	1.19	2.59	2.23
Umatac Salonga	July 15	7	7	100	7	7	14	1.00	1.00	2.00	2.00
Umatac Pajom	July 14	9	5	55.55	16	9	25	3.20	1.80	5.00	2.77
Umatac Madog	July 14, 15	7	5	71.43	12	6	18	2.40	1.20	3.60	2.57
Merizo	July 16	1	1	[100]	4	2	6	4.00	2.00	6.00	6.00
Summary		2,384	2,046	85.82	3,721	2,332	6,053	1.82	1.14	2.96	2.54

Among the individual arrays of embryonic contents there are certain anomalies where a capsule either lacks a germ within or it contains an unfertilized ovum; the aberrant condition can be detected only when developing young are also present in a more interior position in the brood-pouch. Only 10 such instances were discovered in the 2,046 gravid adults, while in *radiolata* there were 23 among 1,313 bearing individuals. The data for the *gibba* instances are given in table 46.

TABLE 46.—*Partula gibba, Guam. Aberrations in the order of embryonic contents.*

Locality.	Number of instances.	Embryonic contents.
Tarague	1	e Y e
	2	e Y e e
	1	Y e Y e e e
Asados	1	e Y e
Barrigarda	2	e Y e
Ukudu	1	e Y e e e
Macajna second	1	e Y e e
Aniguac	1	Y e Y e e

The number of embryonic items ranges from none to 8 at the most, and the full statistics in this connection are duly recorded in table 47.

TABLE 47.—*Partula gibba, Guam. Recorded adults and their embryonic contents.*

	Number of young.				Total.
	0	1	2	3	
Number of eggs:					
0	338	129	36	3	506
1	133	352	131	5	621
2	123	418	239	10	790
3	51	177	126	7	361
4	19	47	28	2	96 } 3,721 eggs. (rows 1–7)
5	4	2	2	.....	8
6	.....	.....	1	.....	1
7	1	.....	.....	.....	1
Total	669	1,125	563	27	2,384 records.
		2,332 young (1–3)			

Summary.	Embryonic contents.								
	0	1	2	3	4	5	6	7	8
Number of adults (=2,384)	338	262	511	603	440	187	37	5	1

We now come to the problems of heredity which are the same as in the case of *radiolata;* but the late development of the distinctive color-phases of *gibba* renders the material less demonstrative than in the other species. One thing is sure, however, namely, that the young snails dissected from the adults are dextral in coil without a single exception; the same is true for all of the adolescents as well as for the adults, and hence there is no evidence that sporadic sinistral mutations occur in *gibba* as they do in some species of the Society Islands.

The central problem in the field of inheritance is concerned with the free interbreeding of the few or many color-classes which make up one or another representative assemblage. If there is evidence of assortative mating on the basis of likenesses in coloration, then there would be some reason to regard the several groups as incipient varieties in the taxonomic sense. But in the previous section on the measurable characters of the color-classes it was argued that the absence of any consistent relation between peculiar statistical features and a distinctive mode of coloration indicated free intercrossing of the varied members of a colony. This conclusion is supported by another consideration, not adduced in the discussion of *radiolata* but equally applicable, namely, the fertile condition of snails belonging to a color-group which is sparsely represented in a flourishing colony. Taking the Aniguac series as an illustration, it appears from the census (table 29) that out of 222 adults, there were 3 castanea and 4 vespera; 1 of the castanea contained no eggs or young, but the other 2 castanea and the 4 vespera were gravid. The chances that the last-named had mated with others of their own respective kinds are so small that their fertile conditions may be taken as proof that they had mated with mitella or bicolor individuals. In the same way the Dededo association provides evidence that phæa snails mate outside of their class. In the Dungcas association, the marginata number 6 and the mitella amount to 29; as all of the former are gravid, it is virtually certain that at least some of them had been fertilized by mitella mates.

When the colors of the embryonic snails are compared with the colors of their parents, class by class, the results provide additional corroboration of the contention that the several color-classes freely interbreed. While the demonstration is not absolute, yet the facts certainly do not favor the alternative view that strict selective mating takes place. By way of approach, we may recall that the early adolescents of unicolor and bicolor are indistinguishable because the ground-colors agree and the distinctive bands of the latter develop only afterwards; they are both whitish or very faintly corneous. The immature shells of mitella are similar to the foregoing in general tones and display only the faintest yellowish deepening on the apical whorls; the young of mitella-rubra are the same. In phæa and castanea, however, the partly-grown individuals are deeper corneous, faint brown in tone, and develop their ruddy or purplish tinges only later in life. The vespera adolescents are likewise light corneous. Finally, the immature marginata are brown-corneous rather than yellowish, and they become lighter instead of darker with age.

If, now, the embryonic young with well-advanced shells are examined, they present three distinguishable modes of coloration. In the first, type *a* (fig. 57, plate 13), the shell is whitish or a very faint whitish-yellow, and is uniform in color. The second mode, type *b* (fig. 58, plate 13), is more yellowish and its extreme apical coils are deeper in tone. In the third, type *c* (fig. 59, plate 13), the ground-color is faint corneous brown, with the apical coils still deeper in color. The numbers of each kind of embryonic young taken from the adults of the several color-classes are given in a comprehensive summary (table 48); but this table can not be taken without many qualifications, chiefly because the several color-classes are not uniformly represented in the same proportionate numbers in all associations, wherefore the opportunities for mutual intercrossing are anything but the same in all parts of the island. Although an analysis on the basis of individual associations is necessary, yet the collective statistics show some correspondence with the facts relating to the adolescents, in so far as the majority of the young of phæa and marginata belong to the darkest group (type *c*) while those of unicolor and bicolor fall mainly in the lightest group. The young of mitella are more frequently whitish and uncolored than would be expected, while the embryonic shells of mitella-rubra are dark in an unlooked-for number of instances.

TABLE 48.—*Partula gibba, Guam. Comprehensive statistics of heredity of color.*

Parent class.	Young.			
	Type *a*, whitish.	Type *b*, yellowish, tinged apex.	Type *c*, brown-corneous.	Total.
unicolor	139	....	....	139
bicolor	171	3	....	174
mitella	947	333	2	1,282
mitella-rubra	77	97	78	252
phæa	95	23	127	245
castanea	34	13	....	47
vespera	183	2	1	186
marginata	....	....	7	7
Total	1,646	471	215	2,332

The detailed analysis begins with the associations which comprise *only* mitella. Combining the material from the upper Ylig, Cemetery, and the two Presidio localities, the number of young of type *a* is 193, while the young of type *b* amount to 70. It is obvious that the definitive mitella mode of coloration is very slow to develop, for certainly we would not be justified in concluding that the 193 young with the type *a* colors would become anything else but mitella adults.

Passing to Tarague, we have an association that comprises 5 color-classes, whose young are distributed among the 3 groups as shown in table 49. The significant points are that all of the embryonic individuals from unicolor and bicolor adults belong to type *a*, that very few young of mitella display tinged apices, and that many of the young of mitella-rubra and phæa are dark-colored. The whole series of adults taken at Tarague amounted to 292 with the proportionate representation of the color-classes as recorded in the census table (table 29), while the replacement generation amounts to 288, which is very nearly equal numerically. Assuming that the association is substantially stable, the embryonic young will develop into adults of the various kinds with about the same numerical relations as those of the parent generation. Now, the adults of the lightest classes numbered 162, while the type *a* young amount to 259; clearly, therefore, some of these embryonic individuals are destined to become other than unicolor or bicolor adults and, from the considerations noted in the foregoing paragraphs, the presumption is that most of such young would have become mitella. Thus intercrossing of the light adults with mitella mates is indicated. Furthermore, the type *a* young of mitella adults far outnumber the type *b* young; judging from the facts in the case of such associations as the upper Ylig, many of the former are certain to become mitella adults, but without question others are destined to remain light and to develop into unicolor or bicolor individuals. Hence the evidence is strengthened that the classes in question interbreed.

The darker adults of the mitella-rubra and phæa classes contribute recruits to the lighter color-groups; as the adolescents of these two types show no real distinctions, it is not surprising that their type *c* young are not distinguishable. It is interesting that the total number of the deepest-colored young is 23, which corresponds closely with that of the two groups of darkest adults, namely, 28.

TABLE 49.—*Partula gibba, Guam. Statistics of heredity of color in representative associations.*

Locality.	Gravid adults.	Young.			
		Type *a*, whitish.	Type *b*, yellowish, tinged apex.	Type *c*, brown-corneous.	Total.
Tarague	unicolor	79	....	....	79
	bicolor	88	....	....	88
	mitella	82	6	1	89
	mitella-rubra	7	....	18	25
	phæa	3	....	4	7
	Total	259	6	23	288
Santa Rosa	mitella	16	10	1	27
	phæa	....	3	45	48
	Total	16	13	46	75
Barrigarda	mitella	4	21	....	25
	mitella-rubra	1	7	....	8
	phæa	16	4	9	29
	vespera	79	....	1	80
	Total	100	32	10	142
Dungcas	mitella	34	....	....	34
	mitella-rubra	2	....	....	2
	marginata	....	....	7	7
	Total	36	....	7	43

The Santa Rosa series is useful because its adults are mitella (25) and phæa (46), together with one sporadic bicolor; the young are recorded in table 49. Allowing for the probability that some of the type *a* among the offspring of mitella might become bicolor, most of them would assuredly develop into mitella adults. Very few of the young of phæa are other than type *c*, but enough belong to type *b* to justify the conclusion that they would grow into mitella adults. By virtue of such mutual contributions, the light young of types *a* and *b* come to number 29 and the dark young amount to 46, which numbers agree remarkably with those of the two contrasted kinds of adults as specified at the beginning of this paragraph.

From the comprehensive table (table 48) it appears that the young of castanea are mainly of type *a*, about one-quarter are type *b*, but none is type *c*. Surely some of these offspring would repeat the parental mode of coloration; apparently the only conclusion to be drawn from the data is that the distinctive colors develop very much later.

For the case of vespera the Barrigarda statistics serve best (table 49): 79 out of 80 young taken from such adults belong to type *a;* the remaining individual is brown-corneous, and it suggests the cross-breeding of vespera with a dark-colored kind, probably phæa. From the light colors of very young vespera adolescents we would expect the embryonic shells to belong to type *a*, as they do. Now, in the Barrigarda adult series, this class amounts to about one-quarter of all, while type *a* young from vespera progenitors number more than half of the total embryonic series, 79 out of 142; presumably the excess of light young beyond the number required to recruit the parent class were destined to become adults of other undeterminable kinds. Thus vespera seems to intercross with contrasted classes.

Finally, it transpires that all of the 7 young taken from the marginata of the Dungcas locality display the type *c* color. As the peculiar adults constitute about one-sixth of the adults collected, it is interesting that their brownish young form very nearly the same proportion of the total embryonic series of this locality. The data are unfortunately too scanty to deserve further discussion.

Despite the difficulties imposed by the late development of the distinctive color characters of the *gibba* classes, and despite the errors which have undoubtedly been made in some instances in assigning the embryonic young to their true classes, there remains a substantial body of proof that the several color-classes of the present species can interbreed mutually.

A. General aspect of Saipan from the west. The culminating summit is Mount Tapochau.

B. Vegetation in Saipan. The bush in the distance is the Sadog Tase area of collection.

CHAPTER VII.

PARTULA GIBBA—SAIPAN.

GENERAL CONSIDERATIONS.

Toward the end of July 1920 the field-work in Guam was interrupted by a journey to the island of Saipan, about 120 miles to the northeast, for the purpose of securing representative series of *Partula gibba* from that territory. After the requisite permission for the visit had been procured from the Foreign Office at Tokyo, the writer accompanied by his son proceeded to Saipan and later returned to Guam on a small naval vessel attached to the station, made available by the interest and courtesy of Governor Wettengel. It was hoped that the intermediate islands of Tinian and Rota could also be explored, because the former, like Saipan, is reported in the literature as a habitat of *gibba;* but hurricane weather and other adverse circumstances made it impossible to land on either of the islands.

During the six days of the sojourn in Saipan, snails were taken from eight characteristic stations on the western side of the island. The animals were found in extraordinary abundance, and their collection was facilitated by the prevailing typhoon weather of the entire period; the overcast skies and almost incessant rains stimulated the animals to greater activity and kept them from retiring to the seclusion which they seek on dry and sunny days. Yet the same climatic conditions prevented a more comprehensive study of the island. While a complete map of the varietal distribution of *gibba* in Saipan can not be made, nevertheless the material is most interesting both on its intrinsic merits and also on account of its general relations to that of Guam.

The geographical position of Saipan and its geological nature have been sufficiently described in Chapter II. The principal points are that the island is a single unit in general contour (plate 8, A), that only the highest portions consist of volcanic materials while the greater bulk is composed of uplifted reef-limestone, and that the massif possesses relatively abrupt borders except on the western side, where a definite coastal plain exists (plate 9). The culminating peak of Mount Tapochau rises to 1,530 feet above sea-level.

The northernmost collecting station was Puntan Muchut near Tanapag Harbor (plate 10). On the flat land only a few score yards from the shore the animals were found in profusion in the thickets along the roadside. Among the dominant plants in that place were the hedge-plant called "camochili" (*Cyclobia*) and the customary "lemoncito" (*Triphasia*).

Next in order was the upland designated Sadog Tase from a small stream of the locality. The collecting-ground was forested and about 150 feet above the sea, and its rock was the typical limestone "cascajo" like that of the northern half of Guam. The general nature of this region and of its drier coastal border is indicated by the illustration (plate 8, B).

Puntan Flores is again a flatland station like Puntan Muchut, and its vegetation is similar to that of the first locality. The snails were found actually within

25 yards of the ocean, thus resembling the animals of such a station of Guam as the outer Presidio locality.

Fanaganam, the next locality, is a well-wooded hill about 250 feet in altitude, situated to the east-northeast of Garapan—the main settlement of Saipan. In ecological respects it agrees with Sadog Tase, and it is well cut off by plantations from the coastal thickets, like those of Puntan Flores.

Torre, "the hill," is a similar but smaller upland east of Garapan, from which collections were secured for the sake of comparison.

Astaman is a higher collecting-ground, at least 500 feet above sea-level, on the westward slopes of the main mountain mass, and nearly west of the summit of Mount Tapochau. Its rock is still limestone, very rough and eroded, with a fairly thick growth of trees. The animals were not found in abundance in that place, despite the heavy rains of the time.

The station called Garapan is another lowland locality with hedge plants and shrubs, immediately to the south of the town so named. It was here that the first collection was made.

The last station in geographical order is Chalankiya, situated about 3 miles south of Garapan on the flat coastal plain, but at some distance back from the strand. This region is the most open anywhere found as the habitation of Partulæ (plate 9, A). The snails were adhering to the leaves of all kinds of trees even when such trees were isolated, while their numbers were greater on the thicker vegetation of the lower scrub. The caladium leaves were especially favored, and in one case 31 animals were found on the under side of a single leaf of the plant (plate 9, B).

In summary, the 8 localities under consideration (plate 10) extend over a total distance, north and south, of 6 miles on the western side of the island; 4 are lowland stations—Puntan Muchut, Puntan Flores, Garapan, and Chalankiya—while the others are upland forested regions. The soil in the case of the first group is alluvial, while at the other and higher places the exposed rock is limestone.

The material from the 8 areas of collection in Saipan comprises 2,666 adults and 664 partly grown individuals; 3,368 young and 4,816 eggs were dissected out of the former, thus providing an abundance of embryonic items for use in connection with certain problems. Departing from the order of treatment of the previous chapter, we will deal first with the qualitative characters of the color-classes, and then take up the statistical analysis of the collections.

But first there is a general feature of the Saipan *gibba* which demands early recognition. It is the rule in *Partula* that the shells attain their maximum size, density, and coloration, and form the flaring lip about the aperture at the same time that they become mature in the reproductive sense. We have seen that *Partula fragilis* is unique in that the late adolescent snails reproduce *before* they develop the lip. The *gibba* of Saipan display the antithetic relation; they gain their full size and form the flaring lip before they proceed to mate and to bear young.

Any series of full-sized shells provided with lips is readily assorted into two groups, in one of which the texture is thinner and the colors are lighter; both of

A. Collecting ground at Chalankiya, Saipan, the most open situation where Partulæ were found.

B. Numerous Partulæ on a single leaf of the caladium, Chalankiya, Saipan. (Published in Natural History, Vol. 21, No. 2, 1921.)

these features are characteristic of the adolescent condition, and in this first group they persist even after the margin is developed about the aperture. The other group comprises "older adults," with thicker shells and with definite coloration. When the two subdivisions are compared on the basis of the statistics of fecundity, the first contains relatively fewer gravid individuals, while the embryonic contents of such as are productive are smaller in number on the average. By way of concrete illustration, we may take the mitella and mitella-rubra color divisions of Chalankiya. Among the "recent adults," the gravid snails amount to 6 per cent, while among the "older adults" they constitute about 99 per cent. The average contents of the first-named are about 3 eggs and young, while the figure is approximately 4 in the case of the latter. Hence the present species as it exists in Saipan constitutes another exception to the rule that the animals complete their shells and attain reproductive maturity at approximately the same time; and the added point of interest is that the exception is just the opposite of that found in *Partula fragilis*.

TABLE 50.—*Partula gibba, Saipan. Census of the collections.*

Series.	Number of adults.							Percentage of adults.						No. of adolescents.
	Total.	unicolor.	bicolor.	mitella.	mitella-rubra.	castanea-rubescens.	castanea-purpurescens.	unicolor.	bicolor.	mitella.	mitella-rubra.	castanea-rubescens.	castanea-purpurescens.	
Puntan Flores	276	4	93	116	14	49	....	1.45	33.69	42.03	5.07	17.75	....	58
Sadog Tase	417	271	72	13	....	61	....	64.99	17.26	3.12	....	14.63	....	117
Puntan Muchut	150	2	76	29	20	23	....	1.33	50.67	19.33	13.33	15.33	....	80
Fanaganam	447	19	309	28	6	75	10	4.25	69.13	6.26	1.34	16.78	2.24	92
Torre	154	....	150	....	....	4	....	....	97.40	....	....	2.60	....	46
Astaman	420	17	352	....	1	50	....	4.05	83.81	....	0.24	11.90	....	77
Garapan	271	....	150	49	....	56	16	....	55.35	18.08	....	20.66	5.90	131
Chalankiya	531	3	2	396	115	15	....	0.56	0.38	74.57	21.66	2.82	....	63
Whole collection	2,666	316	1,204	631	156	333	26	11.85	45.16	23.67	5.85	12.49	0.97	664

COLOR-CLASSES AND THEIR COLONIAL DISTRIBUTION.

In Saipan *Partula gibba* presents 6 color-phases in all, of which 2 are the primary classes unicolor and bicolor, essentially similar to those of Guam. The mitella and mitella-rubra types also occur again substantially as they were found in Guam. The remaining shells are referable to the color-class castanea; while they are further assorted into two orders which are distinguished by their respective ruddy and purplish tints, they do not conform in all details with the rubra and purpurea subdivisions of the class in Guam, and they are given the distinctive names of rubescens and purpurescens. The color composition of the several Saipan series is given in the census (table 50), which comprises the absolute numbers of adults belonging to the several classes and orders, their percentages also, and the total numbers of adolescents.

The unicolor class displays considerable variation as regards the ground-colors (figs. 1 to 10, plate 14). What may be termed the median type is pale-yellowish corneous (figs. 1, 2, plate 14) both on the outside and within. Deepening of the color leads to the full yellowish phase (figs. 3 to 8, plate 14), which is very rarely modified by the addition of brown (fig. 6, plate 14); here too the inner color corresponds closely with that of the outer surface. As in the paler shells, the lip is always pure shining white. Finally, in this class there are shells which are almost white (fig. 9, plate 14), usually as the result of decortication; but some adolescents are so pale as to suggest as early differentiation of this kind of shell (fig. 10, plate 14). From the census table it is apparent that this class varies greatly in its proportionate abundance, from 65 per cent at Sadog Tase to 1.33 per cent at the neighboring station of Puntan Muchut, and to none at Torre and Garapan. Possibly it is a group whose members prefer the higher levels, for the Sadog Tase, Fanaganam, and Astaman series were taken in the bush of greater altitudes. Yet the seeming relation to barometric level may be only a secondary and unimportant feature.

The bicolor class is the dominant one in Saipan, where it preempts the position held by mitella in Guam; it is not only the most abundant but it is also present in all of the representative collections, even though its numbers amount to less than 1 per cent as at Chalankiya. The Fanaganam, Torre, and Astaman series are made up largely of this class. Its distinctive features are the same as in Guam (figs. 11 to 20, plate 14), namely, a revolving band of varying shades of yellowish brown on the whorls of the spire, and a lip that is tinged lightly or darkly, in some correlation with the depth of color of the rotating band. The ground-color is usually corneous as in unicolor (figs. 11 to 13, plate 14); from this the color deepens in other examples to yellowish corneous (figs. 14 to 16, plate 14), but it rarely attains the rich hue of the yellowest unicolor shells. Decortication results in the lightening of the general color (figs. 17 to 19, plate 14), and by virtue of this change the revolving bands stand out more sharply by contrast. The adolescent shells show very little of the band until they have attained a considerable size (fig. 20, plate 14).

The mitella class presents no novel features as compared with that of Guam (figs. 21 to 30, plate 14). The general color grades from corneous to brown-corneous, the color of the spire is light orange at one extreme and red-brown at the other, while the lip is stained with yellow, yellow-brown, or orange-brown. When the shells are decorticated (figs. 28, 29, plate 14) the contrast between the body-whorl and the spire is accentuated. The typical tints of the spire are even later in their development than in the same class of Guam, being evident in a very diluted degree only when the shell is about half-grown (fig. 30, plate 14).

The order distinguished as mitella-rubra is illustrated by figures 31 to 37, plate 14. As in Guam it is characterized by the red suffusion upon the body-whorl, which in a sense is an extension of the deep color displayed by the spire, but the two reddened areas are not always directly continuous (fig. 34, plate 14). The deepest-colored shell (fig. 35, plate 14) is a solitary example from Astaman, and it is unusual in the dark color of the interior wall as well as in the depth of the red color on the outer surface. Decortication sometimes occurs in this class (figs. 36, 37, plate 14). As the distinguishing feature of this order is manifested only when the body-whorl develops, it is impossible to separate the adolescents from those of mitella.

The final class, castanea, comprises within its two orders the darkest and most richly colored shells of the species (fig. 38 to 57, plate 14). As in the major group of Guam with the same name, the general color is brown, and the apex if not the whole spire is deeply colored with brown, red-brown, or purple-brown; it is this feature which distinguishes the shells from those of the so-called phæa class of Guam. The two orders are separated on the basis of their respective ruddy or purplish admixtures to the fundamental brown; such colors are continued upon the flaring lip, often with intensified brilliance. Because the last characteristic is peculiar to the castanea of Saipan, the names rubescens and purpurescens are employed instead of rubra and purpurea, which applied to the corresponding orders in Guam.

The typical shells of castanea-rubescens, with dark red-brown inner and outer surfaces and with full-tinted lip, are shown in figures 41 to 48, plate 14 At Puntan Flores, and more sparingly at a few other places, an interesting variant was found with lightened but still ruddy colors and with the uppermost whorls diluted in color along the suture toward the apex (figs. 38 to 40, plate 14); the inner wall and the lip are also lighter. During their growth, the rubescens shells are at first corneous-brown, with deeply colored apex (figs. 47 to 49, plate 14); later the tones gradually darken, the apical color extends and deepens, and finally the distinctive ruddy color appears as maturity approaches.

The purpurescens order is much less abundant, and unmistakable examples were found only in two localities (figs. 50 to 57, plate 14). The shells are invariably dark purplish brown within as well as without, and the lip is typically faint purple in color. The Fanaganam examples displayed a yellowish instead of a purplish tinge upon the lip (figs. 52, 53, plate 14). Decortication occurs in occasional instances (figs. 55 to 57, plate 14).

The distribution of the foregoing classes is far from uniform as the census table shows (table 50), and the differences displayed by the several local series are entirely independent of the environmental circumstances so far as observation goes. The smaller collection from the isolated summit of Torre comprises only bicolor and castanea-rubescens, while the Fanaganam series includes all 6 of the kinds found in Saipan. The relative numbers of the constituent color-groups vary so that even when the same classes are present in two different areas such as Chalankiya and Puntan Muchut the colonial complexions in color respects are markedly unlike.

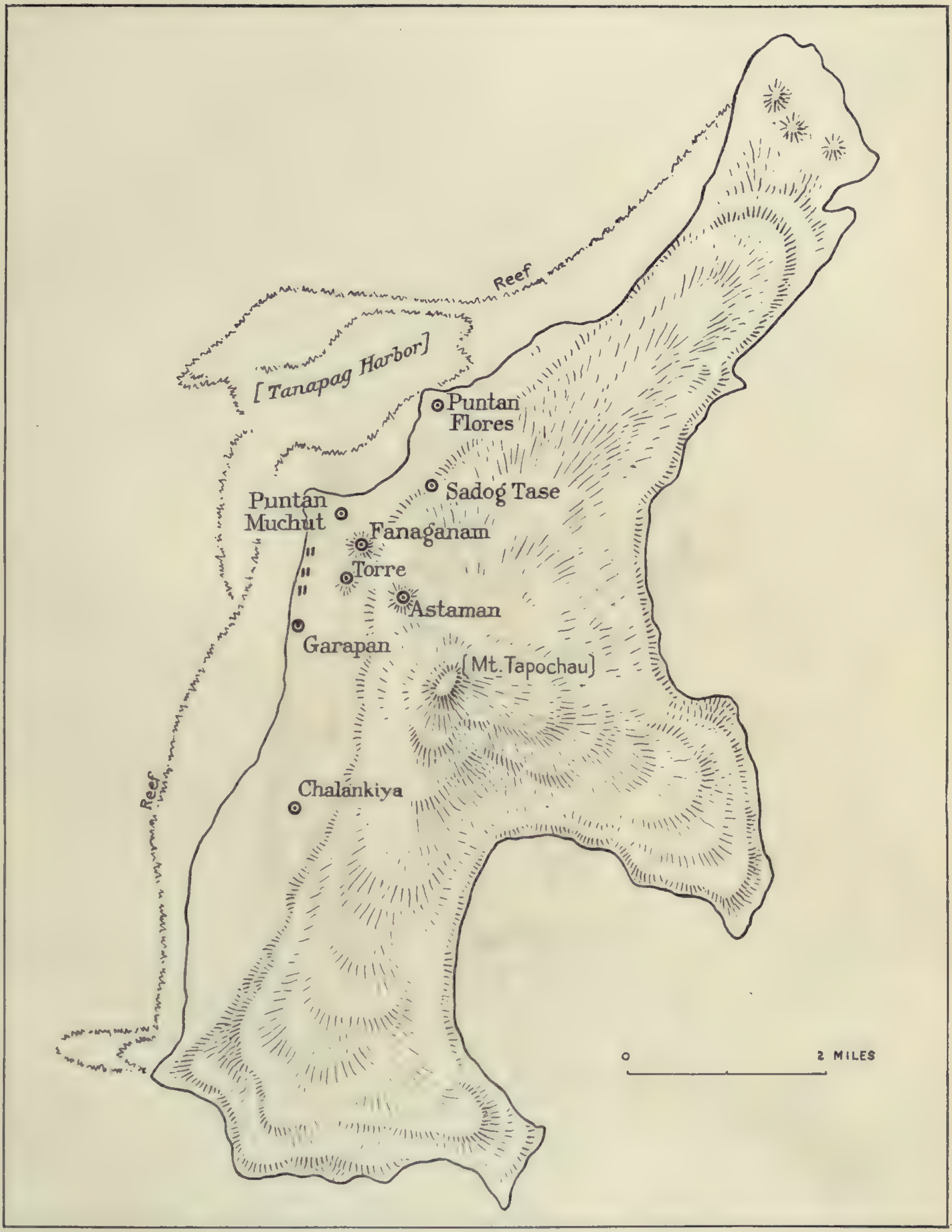
The point has already been noted that it is not the color-class mitella which is universally present, but bicolor; and the same is true of castanea so far as the 8 areas of investigation are concerned; the castenea of Guam were few and scattered. At the extreme northern and southern areas in Saipan, mitella is more abundant than in the intermediate territory, while in the fuller series of stations of Guam it was bicolor that was so distributed. The color-order castanea-purpurescens occurs in the higher locality of Fanaganam and on the flat land south of Garapan with open cultivated areas intervening; it may be a sporadic product from castanea-

TABLE 51.—*Partula gibba, Saipan. Statistical description.*

Series.	No.	Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
RANGE.								
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Puntan Flores	272	15.65 – 18.95	10.7 – 13.9	64.5 – 76.5	9.1 – 11.3	6.5 – 8.5	67.5 – 78.5	52.5 – 61.5
Sadog Tase	403	15.05 – 18.95	10.5 – 13.7	65.5 – 76.5	8.7 – 10.9	6.3 – 8.1	67.5 – 79.5	53.5 – 63.5
Puntan Muchut	146	15.05 – 18.95	10.9 – 13.5	67.5 – 77.5	8.5 – 11.1	6.5 – 8.3	66.5 – 80.5	54.5 – 63.5
Fanaganam	416	14.45 – 19.55	10.5 – 13.3	63.5 – 77.5	8.5 – 11.3	6.3 – 8.1	69.5 – 80.5	50.5 – 62.5
Torre	148	14.75 – 18.35	10.3 – 13.3	64.5 – 77.5	8.5 – 10.9	6.1 – 8.1	69.5 – 80.5	51.5 – 63.5
Astaman	406	15.35 – 19.55	10.7 – 13.9	62.5 – 80.5	8.5 – 11.1	6.5 – 8.5	67.5 – 81.5	51.5 – 62.5
Garapan	269	15.35 – 19.85	10.5 – 13.7	65.5 – 77.5	8.9 – 10.9	6.3 – 8.3	67.5 – 79.5	53.5 – 63.5
Chalankiya	526	14.15 – 18.95	10.1 – 13.3	61.5 – 76.5	8.5 – 10.9	6.3 – 8.1	66.5 – 79.5	52.5 – 61.5
Whole collection	2586	14.15 – 19.85	10.1 – 13.9	61.5 – 80.5	8.5 – 11.3	6.1 – 8.5	66.5 – 81.5	50.5 – 63.5
MEAN VALUE.								
Puntan Flores	272	17.5978±.0271	12.2360±.0212	69.4669±.0895	10.0449±.0166	7.3919±.0139	73.5220±.0909	56.9743±.0644
Sadog Tase	403	16.9855±.0230	12.0697±.0186	70.9466±.0644	9.7074±.0131	7.1823±.0113	73.9417±.0713	57.0087±.0509
Puntan Muchut	146	17.2153±.0385	12.3939±.0275	71.9149±.1093	10.0238±.0214	7.4606±.0184	73.4932±.1268	58.1165±.0839
Fanaganam	416	17.0327±.0292	12.0156±.0182	70.4736±.0842	9.6727±.0142	7.2266±.0105	74.5600±.0722	56.7139±.0703
Torre	148	16.6574±.0303	11.8000±.0308	70.6757±.1301	9.5013±.0227	6.9784±.0188	73.4054±.1187	56.9189±.1009
Astaman	406	17.2882±.0216	12.1350±.0169	70.1232±.0782	9.8266±.0117	7.3719±.0095	74.9433±.0746	56.7340±.0584
Garapan	269	17.1555±.0266	12.2993±.0216	71.6338±.0957	9.8993±.0116	7.2784±.0139	73.5400±.0910	57.5558±.0707
Chalankiya	526	16.7866±.0223	11.6475±.0143	69.3726±.0636	9.5308±.0116	6.9722±.0089	73.0418±.0616	56.2947±.0478
Whole collection	2586	17.0765±.0102	12.0296±.0076	70.3763±.0316	9.7461±.0057	7.2125±.0047	73.8735±.0300	57.1991±.0224
STANDARD DEVIATION.								
Puntan Flores	272	0.6629±.0191	0.5184±.0150	2.1884±.0633	0.4059±.0177	0.3401±.0098	2.2228±.0643	1.5762±.0455
Sadog Tase	403	.6848±.0162	.5530±.0131	1.9161±.0455	.3918±.0092	.3378±.0080	2.1212±.0504	1.5148±.0360
Puntan Muchut	146	.6897±.0272	.4935±.0194	1.9582±.0773	.3841±.0151	.3296±.0130	2.2723±.0896	1.5041±.0593
Fanaganam	416	.8831±.0206	.5504±.0128	2.5458±.0595	.4293±.0100	.3178±.0075	2.1831±.0510	2.1266±.0497
Torre	148	.7096±.0278	.5563±.0218	2.3472±.0920	.4097±.0160	.3390±.0133	2.1414±.0839	1.8196±.0713
Astaman	406	.6471±.0153	.5062±.0119	2.3380±.0553	.3504±.0083	.2841±.0672	2.2284±.0527	1.7467±.0413
Garapan	269	.6485±.0188	.5252±.0153	2.3274±.0677	.4049±.0117	.3383±.0098	2.2137±.0643	1.7204±.0450
Chalankiya	526	.7575±.0157	.4877±.0101	2.1619±.0450	.3947±.0082	.3027±.0063	2.0956±.0435	1.6267±.0338
Whole collection	2586	.7702±.0072	.5726±.0054	2.3862±.0223	.4337±.0040	.3583±.0033	2.2654±.0212	1.6919±.0158

TABLE 52.—*Partula gibba, Saipan. Progressive colonial comparison: mean values.*

Locality.	Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
Puntan Flores	*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
	−0.6123±.0355	−0.1663±.0282	+0.4797±.1103	−0.3375±.0211	−0.2096±.0179	+0.4197±.1155	[+0.0344±.0821]
Sadog Tase							
	+.2298±.0448	+.3242±.0332	+.9683±.1268	+.3164±.0251	+.2783±.0216	−.4485±.1455	+1.1078±.9081
Puntan Muchut							
	−.1826±.0483	−.3783±.0330	−1.4413±.1380	−.3511±.0257	−.2340±.0212	+1.0668±.1459	−1.3926±.1095
Fanaganam							
	−.3853±.0490	−.2156±.0358	[+.2021±.1550]	−.1714±.0268	−.2482±.0215	−1.1546±.1390	[+.2050±.1230]
Torre							
	+.6308±.0448	+.3350±.0351	−.5525±.1518	+.3253±.0255	+.3935±.0211	+1.5379±.1402	[−1849±.1166]
Astaman							
	−.1327±.0343	+.1643±.0274	+1.5106±.1236	+.0727±.0203	−.0935±.0169	−1.4024±.1177	+.8218±.0917
Garapan							
	−.3689±.0347	−.6518±.0259	−2.2612±.1150	−.3985±.0202	−.3062±.0165	−.4991±.1099	−1.2611±.0853
Chalankiya							



Map of Saipan and the areas of collection in that island.

rubescens in each instance, or it may have migrated from the upland station to the coast.

There is no need to develop the argument as to the absence of environmental causation for the observed diversities in colonial color-composition; the foregoing facts are sufficiently demonstrative as they are recorded.

QUANTITATIVE CHARACTERS.

When the several local collections are compared on the basis of their statistical characters they display marked differences that are somewhat unexpected in view of the short distances which separate their respective areas. The figures are here given for the range, mean value, and standard deviation of each of the standard characters in all of the representative series (table 51); owing to the large numbers available, the determinations are more reliable than in most of the local collections at Guam. The order of tabulation is geographical from north to south, and the changes manifested by the several characters in following that order are given with their probable errors in table 52.

TABLE 53.—*Partula gibba. Comparison of Saipan and Guam collections.*

Character.	Saipan *gibba* [No. = 2586]	Guam *gibba* [No. = 2365]	Saipan *gibba* as compared with Guam *gibba*.
MEAN VALUE.			
Shell length, mm	17.0765 ± .0102	16.9966 ± .0102	+0.0799 ± .0144
width, mm	12.0296 ± .0076	11.7986 ± .0078	+.2310 ± .0109
proportions, per cent	70.3763 ± .0316	69.3770 ± .0310	−.9993 ± .0443
Aperture length, mm	9.7461 ± .0057	9.6940 ± .0057	+.0521 ± .0081
width, mm	7.2125 ± .0047	7.1178 ± .0047	+.1047 ± .0067
proportions, per cent	73.8735 ± .0300	73.3233 ± .0302	+.5502 ± .0426
Aperture length ÷ shell length, proportions, per cent	57.1991 ± .0224	56.9199 ± .0215	+.2792 ± .0311
STANDARD DEVIATION.			
Shell length, mm	0.7702 ± .0072	0.7364 ± .0072	+0.0338 ± .0102
width, mm	0.5726 ± .0054	0.5649 ± .0055	[+.0077 ± .0077]
proportions, per cent	2.3862 ± .0223	2.3336 ± .0219	[+.0426 ± .0313]
Aperture length, mm	0.4337 ± .0040	0.4146 ± .0040	+.0181 ± .0057
width, mm	0.3583 ± .0033	0.3373 ± .0033	[+.0110 ± .0046]
proportions, per cent	2.2654 ± .0212	2.1777 ± .0213	[+.0877 ± .0301]
Aperture length ÷ shell length, proportions, per cent	1.6919 ± .0158	1.5500 ± .0152	+.1419 ± .0219

The general conclusion to be drawn from the facts is that the measurable characters vary without reference to environmental circumstances. Taking the matter of altitude, it appears that the lowland series of Puntan Flores is the longest in average measure, but the shells of Chalankiya are also from the coastal plain, and they are the shortest of all, both in absolute dimensions and in the average figure. Conversely, the Sadog Tase shells from the high ground in the north are short, generally speaking, while the Astaman series from even higher levels shows a greater average length in comparison with the colonies from the neighboring areas of Torre and Garapan. Again we may compare an association from the low plain where the soil is alluvial with another from a higher station with exposed limestone rock, without discovering any consistent relation between an absolute or proportionate measure of the shells and such external conditions; a case in point is the comparison of the Astaman and the Garapan series. It is not necessary to multiply illustrations, for the recorded figures clearly demonstrate the conclusion in question.

It is instructive to compare the whole series of shells from Saipan with those from Guam in order to obtain an exact quantitative statement of their differences (table 53). While the Saipan collections were taken from 8 localities only, they are at least representative, even though a more extensive series would undoubtedly yield more or less divergent results. Taking the figures on their merits, the most striking differences are shown in the proportionate measures; the Saipan shells are collectively narrower, with relatively broader apertures, and with a noticeably higher proportionate value of the length of the aperture to that of the whole shell.

TABLE 54.—*Partula gibba, Saipan. Statistics of tooth development.*

Series.	No.	Tooth.		
		None.	Trace.	Small.
Puntan Flores	276	224	46	6
Sadog Tase	417	398	19	....
Puntan Muchut	150	133	16	1
Fanaganam	447	412	35	....
Torre	154	139	14	1
Astaman	420	405	15	....
Garapan	271	218	52	1
Chalankiya	531	397	119	15
Total	2,666	2,326 [87.2 p. ct.]	316 [11.8 p. ct.]	24 [0.9 p. ct.]

The statistics relating to the degree to which the tooth is developed are interesting (table 54). The feature in question is produced very weakly if at all; 87 per cent in Saipan and about 84 per cent in Guam are devoid of any trace, approximately 12 per cent in Saipan and 13 per cent in Guam display a small nodule, while only about 1 per cent in Saipan as compared with nearly 3 per cent in Guam possess a very small tooth. It is the Chalankiya collection which brings up the last figure for the Saipan series of *gibba*.

Finally we come to the ultimate statistical analysis of the Saipan material, which is concerned with the quantitative characters of the several color-classes, colony by colony (tables 55 and 56). The fundamental question at issue is whether a given class, distinguished by its coloration, is also statistically differentiated from its fellows everywhere; the answer is negative. By way of illustration we may follow the **bicolor** and **castanea** classes through the several associations, omitting the small Torre series, contrasting them on the basis of the character of

TABLE 55.—*Partula gibba, Saipan. Statistical description of the color-classes (in part).*

Series.	No.	Mean Value. Shell. Length.	Shell. Width.	Shell. Proportions.	Aperture. Length.	Aperture. Width.	Aperture. Proportions.	Length aperture ÷ length shell, proportions.
		mm.	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
Puntan Flores:								
unicolor	4	16.9250±.2304	11.9000±.1581	72.0000±.7350	9.6500±.1678	7.3000±.0954	75.2500±.4976	57.2500±.3675
bicolor	92	17.5869±.0517	12.3500±.0379	70.0761±.1456	10.0870±.0302	7.4391±.0249	73.7717±.1613	57.1957±.1004
mitella	114	17.5552±.0352	12.1158±.0311	68.9298±.1365	9.9562±.0237	7.2895±.0215	73.3333±.1412	56.6053±.0984
mitella-rubra	13	17.6807±.1286	12.2385±.0999	69.1923±.3623	10.1000±.0639	7.4692±.0654	73.7307±.3962	57.0385±.3250
castanea-rubescens	49	17.7500±.0601	12.3286±.0442	69.4388±.2017	10.1898±.0352	7.4798±.0292	73.2959±.1936	57.3776±.1624
Sadog Tase:								
unicolor	261	16.9144±.0271	12.0303±.0228	71.0479±.0825	9.6448±.0147	7.1291±.0132	73.8448±.0872	56.9061±.0593
bicolor	70	16.9186±.0609	11.9686±.0441	70.5428±.1532	9.6714±.0354	7.1943±.0281	74.4143±.1950	57.0571±.1452
mitella	13	16.4731±.1273	12.4846±.0796	71.1154±.3635	10.0538±.0765	7.3923±.0715	73.6538±.4205	57.1154±.2699
castanea-rubescens	59	16.2720±.0551	12.2729±.0464	70.9407±.1365	9.9588±.0311	7.3576±.0282	73.8729±.1533	57.3813±.1294
Puntan Muchut:								
unicolor	2	18.0500±.0	13.0000±.1431	72.0000±.7154	10.2000±.0447	7.7000±.0954	75.0000±.1923	57.0000±.2384
bicolor	74	17.0568±.0517	12.3405±.0397	72.2703±.1668	9.9514±.0297	7.4189±.0237	73.5946±.1558	58.2433±.1334
mitella	28	17.4286±.0842	12.4571±.0538	71.2500±.2518	10.1214±.0502	7.5286±.0504	72.1786±.2386	57.8215±.1671
mitella-rubra	19	17.5447±.1186	12.5105±.0878	71.3947±.2835	10.2368±.0631	7.6789±.0540	75.0263±.4090	58.2895±.1708
castanea-rubescens	23	17.1239±.0805	12.3261±.0600	72.0217±.2012	9.9435±.0469	7.3087±.0418	73.3691±.3273	58.0217±.1801
Fanaganam:								
unicolor	18	17.3833±.1227	11.9666±.1011	68.5556±.3244	9.7555±.0668	7.2333±.0653	73.4445±.3200	56.1667±.2596
bicolor	287	17.1552±.0356	12.0756±.0219	70.2840±.1070	9.6868±.0172	7.2345±.0125	74.5801±.0845	56.3363±.0871
mitella	25	16.8980±.1328	12.0840±.0678	71.6600±.3021	9.6680±.0584	7.2840±.0381	75.3800±.3311	57.3000±.2158
mitella-rubra	6	16.2500±.1066	11.6333±.0609	71.5000±.1589	9.2666±.0668	7.0333±.0259	75.1666±.4680	57.3333±3700
castanea-rubescens	70	16.6229±.0590	11.8513±.0425	71.2571±.1520	9.6714±.0337	7.2115±.0258	74.3429±.1906	58.1143±1411
castanea-purpurescens	10	16.5500±.1593	11.5800±.1246	70.3000±.4938	9.4800±.1013	7.0600±.0911	75.1000±.5895	56.9000±.3594
Torre:								
bicolor	144	16.6646±.0401	11.8000±.0310	70.6528±.1293	9.4945±.0227	6.9736±.0187	73.4028±.1205	56.8680±.0986
castanea-rubescens	4	16.4000±.1676	11.8000±.2361	71.5000±1.1923	9.7500±.1744	7.1500±.1536	73.5000±.6745	58.7500±.9650
Astaman:								
unicolor	17	17.7676±.1309	12.5941±.0919	70.8529±.4556	10.1237±.0717	7.6882±.0687	75.5588±.4179	57.0294±.2578
bicolor	339	17.2553±.0234	12.0752±.0180	69.9130±.0836	9.7974±.0125	7.3554±.0099	75.0339±.0771	56.6593±.0653
mitella-rubra	1	17.1500	11.9000	70.5000	9.9000	7.5000	74.5000	56.5000
castanea-rubescens	49	17.3520±.0561	12.3857±.0410	71.3163±.2084	9.9245±.0300	7.3735±.0251	74.1122±.2610	57.1326±.1427
Garapan:								
bicolor	150	17.1220±.0376	12.2614±.0294	71.5467±.1279	9.8400±.0217	7.2480±.0185	73.6800±.1215	57.3400±.0868
mitella	49	17.2051±.0644	12.3286±.0538	71.6244±.2000	9.8429±.0410	7.2378±.0337	73.5415±.2022	57.0307±.1594
castanea-rubescens	56	17.0589±.0451	12.3571±.0425	72.3214±.2030	10.0214±.0324	7.3893±.0287	73.6607±.1902	58.5357±.1523
castanea-purpurescens	15	17.6900±.0693	12.3667±.0811	69.9667±.4163	10.2200±.0593	7.3000±.0492	71.7000±.3773	57.7667±.3333
Chalankiya:								
unicolor	3	16.8500±.0953	11.7666±.2044	68.8333±.9712	9.6333±.0734	6.8333±.0734	70.8333±.1836	55.8333±.1836
bicolor	2	16.2500±.0	11.1000±.0	68.5000±.0	9.7000±.0954	6.9000±.0	71.0000±.7154	53.0000±.2384
mitella	393	16.7676±.0247	11.6211±.0163	69.2990±.0734	9.5173±.0126	6.9621±.0101	72.9377±.0357	56.3143±.0535
mitella-rubra	113	16.8765±.0551	11.7566±.0325	69.6239±.1392	9.5814±.0300	7.0168±.0208	73.4646±.1257	56.3053±.1151
castanea-rubescens	15	16.6700±.1214	11.5666±.0667	69.3666±.3412	9.1000±.0577	6.9400±.0420	73.3000±.3617	56.2333±.2229

shell length with the whole local assemblage of which, naturally, they are both components. At Puntan Flores, bicolor is average, while the dark class is composed of longer shells; at Sadog Tase the former is again average, but the latter shows a very much lower figure. At the next station of Puntan Muchut both classes are noticeably shorter than their associates and bicolor is especially so; but at Fanaganam the former is longer and the latter is shorter, in comparison with the general colonial average. It is not necessary to complete the sequence to realize that the structural character in question varies independently of the color qual-

TABLE 56.—*Partula gibba, Saipan. Statistical description of the color-classes (cont.).*

Standard Deviation.								
Series.	No.	Shell.			Aperture.			Length aperture ÷ length shell, proportions.
		Length.	Width.	Proportions.	Length.	Width.	Proportions.	
Puntan Flores:		*mm.*	*mm.*	*p. ct.*	*mm.*	*mm.*	*p. ct.*	*p. ct.*
unicolor	4	0.6833±.1629	0.4690±.1118	2.1794±.5197	0.4975±.1186	0.2828±.0674	1.4756±.3518	1.0897±.2598
bicolor	92	.7354±.0365	.5394±.0268	2.0706±.1029	.4291±.0213	.3548±.0176	2.2941±.1140	1.4275±.0710
mitella	114	.5880±.0248	.4929±.0220	2.1603±.0965	.3751±.0167	.3405±.0152	2.2357±.0998	1.5581±.0696
mitella-rubra	13	.6877±.0909	.5343±.0706	1.9369±.2562	.3419±.0452	.3495±.0462	2.1178±.2801	1.7372±.2298
castanea-rubescens	49	.6240±.0425	.4589±.0312	2.0938±.0906	.3660±.0249	.3029±.0206	2.0099±.1369	1.6859±.1148
Sadog Tase:								
unicolor	261	.6497±.0191	.5455±.0161	1.9775±.0583	.3519±.0104	.3177±.0093	2.0899±.0616	1.4209±.0419
bicolor	70	.7558±.0430	.5471±.0312	1.9006±.1083	.4398±.0250	.3492±.0198	2.4186±.1379	1.8019±.1027
mitella	13	.6807±.0900	.4258±.0563	1.9430±.2570	.4088±.0541	.3812±.0505	2.2479±.2973	1.4429±.1908
castanea-rubescens	59	.6277±.0389	.5291±.0328	1.5543±.0965	.3543±.0220	.3211±.0199	1.7457±.1084	1.4739±.0915
Puntan Muchut:								
unicolor	2	.0	.3000±.1012	1.5000±.5058	.1000±.0337	.2000±.0674	2.5000±.8431	0.5000±.1686
bicolor	74	.6597±.0365	.5061±.0281	2.1279±.1179	.3793±.0210	.3029±.0167	1.9876±.1101	1.7014±.0943
mitella	28	.6608±.0595	.4221±.0380	1.9753±.1780	.3940±.0355	.3954±.0356	1.8719±.1676	1.3108±.1181
mitella-rubra	19	.7667±.0838	.5675±.0621	1.8323±.2004	.4081±.0446	.3488±.0382	2.6431±.2892	1.1040±.1208
castanea-rubescens	23	.5727±.0569	.4265±.0424	1.4407±.1422	.3334±.0331	.2977±.0295	2.3276±.2314	1.2809±.1273
Fanaganam:								
unicolor	18	.7717±.0867	.6859±.0715	2.0405±.2294	.4206±.0472	.4109±.0462	2.0131±.2263	1.6329±.1835
bicolor	287	.8785±.0252	.5398±.0155	2.6639±.0763	.4259±.0121	.3090±.0088	2.0862±.0597	2.1487±.0616
mitella	25	.9847±.0930	.5025±.0479	2.2393±.2136	.4333±.0413	.2824±.0269	2.4547±.2341	1.6000±.1526
mitella-rubra	6	.3873±.0754	.2212±.0430	0.5773±.1123	.2427±.0472	.0943±.0183	1.6997±.3309	1.3437±.2616
castanea-rubescens	70	.7321±.0417	.5279±.0300	1.8856±.1075	.4185±.0238	.3201±.0182	2.3642±.1348	1.7508±.0998
castanea-purpurescens	10	.7469±.1126	.5845±.0881	2.3151±.3491	.4749±.0716	.4271±.0644	2.7640±.4165	1.6852±.2541
Torre:								
bicolor	144	.7133±.0283	.5518±.0219	2.3013±.0914	.4041±.0160	.3339±.0132	2.1451±.0852	1.7546±.0697
castanea-rubescens	4	.4971±.1185	.7000±.1669	3.5355±.8431	.5171±.1233	.4555±.1086	2.0000±.4769	2.8614±.6823
Astaman:								
unicolor	17	.8004±.0925	.5620±.0650	2.7851±.3221	.4385±.0507	.4199±.0488	2.5546±.2955	1.5760±.1823
bicolor	339	.6380±.0165	.4914±.0217	2.2812±.0591	.3416±.0088	.2696±.0070	2.1052±.0545	1.7827±.0462
mitella-rubra	1	....	....	....	....	....	....	....
castanea-rubescens	49	.5826±.0396	.4257±.0290	2.1635±.1473	.3120±.0212	.2608±.0177	2.7091±.1845	1.4808±.1009
Garapan:								
bicolor	150	.6818±.0266	.5335±.0208	2.3190±.0904	.3931±.0153	.3366±.0131	2.2032±.0859	1.5751±.0614
mitella	49	.6685±.0455	.5584±.0380	2.0763±.1414	.4257±.0290	.3502±.0238	2.0991±.1430	1.6549±.1127
castanea-rubescens	56	.5004±.0319	.4716±.0300	2.2528±.1435	.3599±.0229	.3183±.0203	2.1109±.1345	1.6899±.1077
castanea-purpurescens	115	.3980±.0490	.4657±.0573	2.3907±.2943	.3409±.0419	.2828±.0348	2.1664±.2668	1.9137±.2357
Chalankiya:								
unicolor	3	.2449±.0674	.5249±.1445	2.4940±.6867	.1886±.0519	.1886±.0519	0.4714±.1298	0.4714±.1298
bicolor	2	.0	.0	.0	.2000±.0674	.0	1.5000±.5058	0.5000±.1686
mitella	393	.7264±.0174	.4792±.0115	2.1574±.0519	.3721±.0089	.2976±.0071	2.0507±.0252	1.5738±.0378
mitella-rubra	113	.8694±.0389	.5120±.0230	2.1946±.0984	.4731±.0212	.3277±.0147	1.9819±.0889	1.8137±.0814
castanea-rubescens	15	.6735±.0858	.3699±.0471	1.8927±.2412	.3200±.0408	.2332±.0297	2.0066±.0435	1.2365±.1576

ities of the two classes; the same is true for the other characters of the two classes, and for the quantitative characters oi the remaining color-classes as well. In general, the statistical qualities of the color-classes, like the distinctive forms of coloration themselves, disclose no relation to ecological conditions that would indicate a causative value of such external influences.

The colors of the lips in the several classes are recorded in summary form in table 57. The obvious points are (1) the **unicolor** shells are universally white in this respect, (2) the **bicolor** and **mitella** shells are predominantly yellow, (3) the mitella-rubra are always yellow, (4) the castanea-rubescens are red in correspondence with their general ruddy coloration, save in a few exceptional instances, while finally (5) the castanea-purpurescens shells are usually light purple, but occasional specimens are red, yellow, or white.

The degree to which the tooth is developed in the several color-classes (table 57) does not vary significantly. The large number of mitella with a distinct but very small tooth is due to the prevalence of this class in the Chalankiya association which has a high colonial average for the structure in question.

TABLE 57.—*Partula gibba, Saipan. Statistics of lip color and tooth development.*

Series.	No.	Color of lip.				Tooth.		
		White.	Yellow, yellow-brown.	Red.	Purple.	None.	Trace.	Small.
unicolor	316	316	....	....	....	296	20	....
bicolor	1,204	135	1,069	....	....	1,102	99	3
mitella	631	18	613	....	....	495	121	15
mitella-rubra	156	....	156	....	....	113	39	4
castanea-rubescens	333	....	....	329	4	297	34	2
castanea-purpurescens	26	1	5	2	18	23	3	....
All	2,666	470	1,843	331	22	2,326	316	24

EMBRYONIC MATERIAL.

The eggs and young taken from the adult individuals are abundant and the latter are particularly valuable for a problem that was difficult of direct solution in the case of the Guam series, namely, the question as to the mutual crossing of the color-classes. The collections were made late in July of 1920, when the conditions were apparently very favorable, for the animals seemed to be at the height of their reproductive cycle.

The full data of fecundity are given in table 58. Of the 2,585 recorded individuals about 85 per cent proved to be gravid, in close agreement with the Guam *gibba*, among which approximately 86 per cent were actively bearing. The repro-

TABLE 58.—*Partula gibba, Saipan. Statistics of fecundity.*

Locality.	Date (1920).	Records.	Gravid.		Embryonic contents.			Average for gravid.			Average for all.
			No.	Per cent.	Eggs.	Young.	Total.	Eggs.	Young	Total contents.	
Puntan Flores	July 28	273	226	82.8	454	330	784	2.01	1.46	3.47	2.87
Sadog Tase	July 28	412	341	82.8	721	499	1,220	2.11	1.46	3.57	2.96
Puntan Muchut	July 28	145	99	68.3	187	174	361	1.89	1.76	3.65	2.49
Fanaganam	July 29	426	365	85.7	632	529	1,161	1.73	1.45	3.18	2.72
Torre	July 29	130	110	85.4	241	176	417	2.19	1.60	3.79	3.21
Astaman	July 30	407	391	96.1	1,077	732	1,809	2.76	1.87	4.63	4.44
Garapan	July 27	269	192	71.4	330	309	639	1.72	1.61	3.33	2.37
Chalankiya	July 27	523	473	90.4	1,171	619	1,790	2.47	1.31	3.78	3.42
Summary	....	2,585	2,197	84.99	4,813	3,368	8,181	2.19	1.53	3.72	3.16

ductive rate proved to be slightly higher than in the same species of Guam, as the average embryonic contents numbered 3.72 as compared with 2.96 for the southern island. We may note that the proportion of eggs to young snails is about 1.4 to 1, while in the Guam series it was 1.6 to 1; if the figures are taken at their face value this means that in Saipan the species was slightly more advanced in its reproductive cycle. By way of amplification table 59 records the complete distribution of the embryonic contents, eggs and young, both in tabular form and in summary.

TABLE 59.—*Partula gibba, Saipan. Recorded adults and their embryonic contents.*

	Number of young.						Total.	
	0	1	2	3	4	5		
Number of eggs:								
0	388	73	32	1	....	....	494	
1	90	191	186	21	2	1	491	4,813 eggs.
2	95	266	351	71	5	....	788	
3	41	168	258	70	6	2	545	
4	19	68	103	37	1	....	228	
5	2	10	15	8	....	....	35	
6	....	1	3	....	....	....	4	
Total	635	777	948	208	14	3	2,585 records.	
	....	3,368 young.						

Summary.	Embryonic contents.								
	0	1	2	3	4	5	6	7	8
Number of adults (=2,585)	388	163	318	494	559	401	189	59	14

More frequently than in Guam the order in which the embryonic contents lie in the brood-pouch is irregular, in the sense that less-developed or undeveloped items are nearer to the birth aperture than older ones. In all, 45 instances were discovered, as enumerated in table 60. Particular interest attaches to the two unmistakable instances in the Chalankiya series where "egg-young" (indicated in the table as *ey*) were found beyond much older embryonic snails, because in these cases we have true "anachronisms" where a capsule containing a newly fertilized egg is actually pushed past one formed earlier; in by far the majority of instances the "egg" beyond a "young" snail is really a capsule devoid of an inclosed zygote or it contains a fertilized germ which has failed to develop.

The data of heredity are lastly to be considered. Here as everywhere else in the Mariana species the embryonic snails are universally dextral like their parents. While it is not permissible to assert that sinistral offspring are never produced, the material in hand fails to disclose a single instance of a reversal in spirality.

The qualities of color in *gibba* are not such as to provide ideal material for the determination of the hereditary relations between parents and offspring in such respects, but nevertheless there is positive proof that at least some of the color-classes interbreed. The embryonic shells appear in two phases which are quite clearly contrasted; they are either very light and almost colorless or they are distinctly brown. Bringing together all of the data, the absolute numbers of both kinds produced by parents of the several classes are given in table 61. From the returns it appears that the lighter colored classes produce a preponderance

TABLE 60.—*Partula gibba, Saipan. Aberrations in the order of embryonic contents.*

Locality.	Number of instances.	Embryonic contents.
Puntan Flores...........	1	e Y e e
Sadog Tase.............	1	e Y e
	3	e Y e e
	2	e Y e e e
	1	e e Y e e
	1	e e Y Y e e
	1	e e Y e e e e
	1	Y e Y e e
Puntan Muchut.........	1	e Y e
Fanaganam.............	2	e Y e
	2	e Y e e
	1	e Y e e e
	1	e Y Y e e
	1	e Y Y Y e
	1	Y e Y e
Torre..................	1	e Y e e
	1	e Y Y e e e
Astaman...............	2	Y e Y e e
	1	Y e Y e e e
Garapan...............	1	e Y
	2	e Y e
	1	Y e Y e
	1	Y e Y e e e
Chalankiya.............	3	e Y e e
	6	e Y e e e
	1	e Y Y e e
	1	e e Y e e e
	1	e ey Y e e
	1	e ey Y Y e
	2	Y e Y e e e

TABLE 61.—*Partula gibba, Saipan. Comprehensive statistics of heredity of color.*

Parent class.	Young.		
	White.	Brown.	Total.
unicolor..................	455	3	458
bicolor....................	1,550	24	1,574
mitella...................	672	3	675
mitella-rubra.............	186	2	188
castanea.................	58	415	473
Total...........	2,921	447	3,368

of light young and that the dark castanea adults bear dark young in the main; but some members of both adult divisions contribute young of the contrasted phase to the following generation. Either such cross-production is spontaneous, or it is the result of cross-breeding, and the latter conclusion certainly seems the more probable; in either case, however, we may be sure that the lighter and darker kinds of adults are not separated by physiological barriers.

Before discussing the subject further, we may recall the characters of the adolescent snails. In the first place the distinction between the rubescens and the purpurescens phases of castanea is manifested only late in development, and hence we deal with the castanea class as a whole in contrast with its lighter associates. The latter are not distinguishable in their earlier adolescent conditions, as we have shown earlier, and *a fortiori* it is not to be expected that their embryonic shells would be unlike. Presumably, therefore, the lighter young recorded in table 61 would have developed into unicolor, bicolor, mitella, or mitella-rubra adults, and the brown young would have become castanea.

TABLE 62—*Partula gibba, Saipan. Proportions of the light and dark classes in adult and offspring generations.*

Series.	Adult generation, per cent.		Offspring generation, per cent.	
	Light classes.	Dark classes.	Light classes.	Dark classes.
Puntan Flores....	82.25	17.75	83.6	16.4
Sadog Tase......	85.37	14.63	84.4	15.6
Puntan Muchut..	84.67	15.33	82.8	17.2
Fanaganam......	80.98	19.02	85.4	14.6
Torre...........	97.40	2.60	97.7	2.3
Astaman........	87.86	12.14	86.6	13.4
Garapan.........	73.44	26.56	72.5	27.5
Chalankiya......	97.18	2.82	96.6	3.4
All...........	86.50	13.50	86.7	13.3

Having established the fact that light-colored and dark-colored snails interbreed, we may carry the argument further, despite the real adverse circumstances. Each association must be taken individually, for the proportions of the two main color-groups vary greatly from place to place (table 62). Now, the proportions of light and dark young produced by the several adult series approximate so closely to the figures for the two groups of adults that there is not 2 per cent of discrepancy in any case (table 62); this means that each colony is relatively stable from generation to generation so far as the numbers of the light and dark kinds are concerned. This color equilibrium is maintained not by the absolute restriction of offspring to their parental modes of coloration but by reciprocal contributions of contrasted young. But in Sadog Tase the light group of adults is made up largely of unicolor, in Astaman bicolor is the most abundant, while at Chalankiya the mitella and mitella-rubra adults predominate; it is therefore evident that the castanea class is genetically inter-related with all of the classes more lightly colored than itself. While it is not possible to prove directly that the lighter classes such as unicolor and bicolor interbreed, by analogy it is highly probable that they also are capable of intercrossing.

CHAPTER VIII.

SUMMARY.

RÉSUMÉ OF INTRODUCTION.

The investigations described in the present volume are concerned with the natural history of the representatives of the genus *Partula* which dwell in the Mariana Islands, Guam and Saipan. An earlier volume on the species of Tahiti developed the methods and recorded the results of an intensive study in the present headquarters of the genus in southeastern Polynesia; as the Mariana Islands lie far in the western Pacific Ocean and quite at the northwestern limit of the tropical area in which the genus ranges, the present study provides the requisite materials for a comparison which serves to bring into clearer relief such principles of ecology, distribution, and relationship as are common to the species of widely separated regions.

RÉSUMÉ OF CHAPTER I.

The geographical conditions throughout Oceania are ideal for the study of the correlation between the resemblances or differences exhibited by related species and the proximity or isolation of their territories; with rare exceptions, each group of islands bears its own distinctive species and each island within a group possesses its characteristic forms, while different localities of one and the same island may be inhabited by diverse species or varieties. The Mariana Islands are the dry peaks of a submarine range which extends in the form of an upright bow for a distance of over 400 miles; they are remote from other groups except to the north, and their present disconnection is emphasized by the great depths of the ocean in their vicinity. Their very isolation argues against their population by *Partula* immigrants from another group of islands.

The northern members of the Mariana Group have been formed by volcanic action in relatively recent geologic times, and they are devoid of Partulæ; the older southern elements are composed partly of volcanic materials and partly of coral limestone upraised above the sea, and they only are inhabited by the larger land-snails. The northern part of Guam is a plain, almost exclusively calcareous, in marked contrast with the higher southern region of volcanic mountains and slopes where the lower levels only are composed of limestone. Saipan is a unitary conical mass of double geological nature, like the southern part of Guam.

The climate is hot and wet, with a somewhat definite seasonal cycle. As the calendar summer approaches, the northeast trade-winds give place to the southwest monsoon; accordingly the temperature rises and the rains become more copious until early autumn, when the reverse changes occur. The thick growth of the forests constitutes the most favorable habitation of Partulæ, with the requisite conditions of shade, moist atmosphere, and humus for food. The thickets about the plantations and villages are less suitable, while the open grasslands of the savannas can not be tolerated by the snails. The botanical characters of the plants among which the animals are found are negligible, saving only that they must be adapted to growth in close associations. Thus the habitations of Partulæ in the Mariana Islands as elsewhere are determined directly by the occurrence of suitable high vegetation of greater or lesser density, and indirectly by the physiographic and climatic circumstances which condition the distribution of the available areas of vegetation. There are no discernible faunal elements which affect the research organisms.

RÉSUMÉ OF CHAPTER II.

Field-work was carried on in Guam during the greater part of July and August of 1920, and a brief visit was made to Saipan in the last week of July. Nearly 10,000 snails were collected, and from the viviparous adults an abundance of embryonic material was dissected for use in connection with certain problems of heredity. The representative collections were taken from 39 localities of Guam and from 8 of Saipan.

Guam is inhabited by 4 species, 3 of which are not known to occur elsewhere. *Partula salifana* is a new discovery, and was found only on the remote and isolated peak of Mount Salifan, from which it is named. The old species called *P. fragilis* by Férussac was rediscovered in small numbers and in restricted areas; it has remained virtually "lost" for a full century. *Partula radiolata* Pfeiffer is abundant and widespread, and its intrinsic diversification has been carried far. The last species, *P. gibba* Férussac, provides the largest number and the greatest variety of subordinate forms. Saipan is populated only by *P. gibba*, which exists in considerable number; the material obtained in that place is important on its own merits and also because it is available for an inter-island comparison with the members of the identical species of Guam.

The methods of analysis are the same which were employed in the study of the species of Tahiti. The standard characters of the shells were measured and the statistical constants were determined according to the accepted biometric procedure, in order to obtain precise quantitative descriptions of the local groups and also to discover real differences which would have escaped observation otherwise. In detail, the investigation is concerned with the qualitative and quantitative characters of the shells, with the variations of these characters, and with the distribution of the species and of their varieties, always with due regard to the ecological conditions and to the problem as to the relative value to be assigned to the congenital and the external factors of organic constitution.

RÉSUMÉ OF CHAPTER III.

The new species, *P. salifana*, is noteworthy on account of its close restriction to the bush near the summit of Mount Salifan. Its numbers are sparse, like those of the associated species in the same area. The shell is conventional in form and heavy in texture, and in these respects it strongly resembles the prevalent types of the Society Islands of remote Polynesia. One very important point is the existence of this heavy-shelled species in a region where there is no limestone, because it is clearly evident in this case that the character of the soil is not a factor of the degree to which the shell thickens. The embryonic young attain their colors early in this species.

RÉSUMÉ OF CHAPTER IV.

Férussac gave no figures of the form described by him in 1821 as *P. fragilis*, but his terse description leaves no doubt that his specimens belonged to the species now found mainly in the northern part of Guam in very small numbers. In 1894 von Moellendorf described the same species as *P. quadrasi*, also without giving any figures of the shell or of the animal. The snails are small, and their shells are thin and diaphanous; they are most abundant in the northern region where the rock is limestone, but the geological circumstance has no more relation to the texture of the shell in this case than it has in the contrasted instance of *salifana*. The body within is boldly maculated and its colors may be seen through the shell; hence the appearance of the animals in life is very different from that of any other Guam type. The upper coils are tumid and the last whorl is swollen somewhat as in *P. turgida* of Raiatea in the Society Islands.

But the most notable peculiarity of the species is its precocious reproductive activity. In no other known species are eggs formed before the flaring lip about the aperture is constructed as the conventional sign of maturity; in *fragilis*, all of the animals with completed shells bore young and eggs, while in addition all of the "adolescent" individuals over 12 mm. in length were gravid, despite the fact that their shells lacked the finished lip. Finally, in contrast with its associates of the Mariana Islands, *fragilis* produces egg-capsules whose walls are fully impregnated with calcareous substance, as in the prevalent Tahitian species.

RÉSUMÉ OF CHAPTER V.

Partula radiolata is a well-represented species which now spreads throughout nearly all parts of Guam; hence it is available for a study of geographic distribution as the foregoing species were not. Its proportionate numbers are not the same in all of the local associations, but its variations in frequency are not related in any discoverable manner to ecological conditions.

The statistical characters of the individual colonies and of the combined regional populations are fully recorded so as to give a sure basis for future studies of a similar kind which may disclose the occurrence and nature of any evolutionary changes during the interim. The colonial qualities vary without any relation to external circumstances; under the identical conditions of contiguous areas, the *radiolata* groups may show marked differences, while similar statistical features are displayed by the members of colonies which thrive in diverse ecological regions.

Variations in color and color-pattern are even more striking than in the measurable characters of the shells. Six color-groups are now found in Guam and three of these are newly distinguished; they are given distinctive names, not of taxonomic significance, which refer to their characteristic colors or patterns. The local associations of *radiolata* differ much among themselves as regards color composition, and in two ways; the kinds of color-classes present may be very unlike even in neighboring associations, while in addition the proportionate numbers vary greatly even when the same kinds are present in comparable colonies. It is even more evident than in the case of the structural qualities that the environmental circumstances are negligible as factors of the individual and colonial color characters, and as factors of the structural variations of the shells belonging to different color-groups.

A seasonal cycle of reproductive activity is indicated by the data of fecundity. With the advent of hotter weather and of heavier rains in late spring, the animals enter a breeding period which apparently continues throughout the calendar summer. The data of heredity prove that the several color-classes intercross, and that they are not so isolated physiologically as to be real taxonomic varieties.

RÉSUMÉ OF CHAPTER VI.

Partula gibba Férussac is designated by Pilsbry as the most typical among the species which occur in the Mariana Islands. It is the most abundant species in Guam and is the only one known to exist in other islands of the group. The phenomena of its geographical diversification are the same as in the case of *radiolata*, and the conclusion drawn from such data is identical in principle. The animals occur nearly everywhere in the suitable areas of vegetation in Guam; their varying numbers and the statistical characters of the shells of the several colonies are independent of the environment, so far as observation goes.

This species surpasses *radiolata* in the range of its variations in color. Seven primary color-classes are recognized, and in four of these there are distinguishable color-orders. These groups, duly named on the basis of their distinctive colors, are not accorded the status of taxonomic varieties, because their differences in color are not deemed sufficient to warrant such a course. Colonies differ greatly among themselves as regards the number of color groups they comprise and also as regards the relative number within their constituent classes and orders. Furthermore, the several color-groups differ in their total numerical abundance in Guam and in the extent of the territories throughout which they range; some are virtually ubiquitous, while another may be found in a single locality only. The statistical characters of the color-groups, like the qualities of coloration, are not influenced by the surrounding ecological conditions.

A seasonal reproductive cycle is not clearly marked in the case of *gibba*, but probably the animals are periodic in their breeding habits. While the data of heredity are not so demonstrative on account of the slow development of the definitive modes of coloration in this species, yet there are many considerations which prove that the several color-classes interbreed, as in the case of *radiolata*.

RÉSUMÉ OF CHAPTER VII.

The representatives of *P. gibba* which were secured in Saipan vary colonially in their statistical characters and in their qualities of color. Four of the Guam color-groups reappear in Saipan and constitute the bulk of the Partula population; the remaining snails are placed within the limits of another of the Guam classes, but they display a different ordinal mode of coloration. The *gibba* from Saipan are collectively different from those of Guam in their statistical characters, although the degrees of difference are not very large. In brief, the inter-island comparison of the *gibba* representatives discloses a differentiation in accordance with the separation of the two localities, manifested by the existence of certain endemic color-forms in each place and by the distinctions in quantitative respects.

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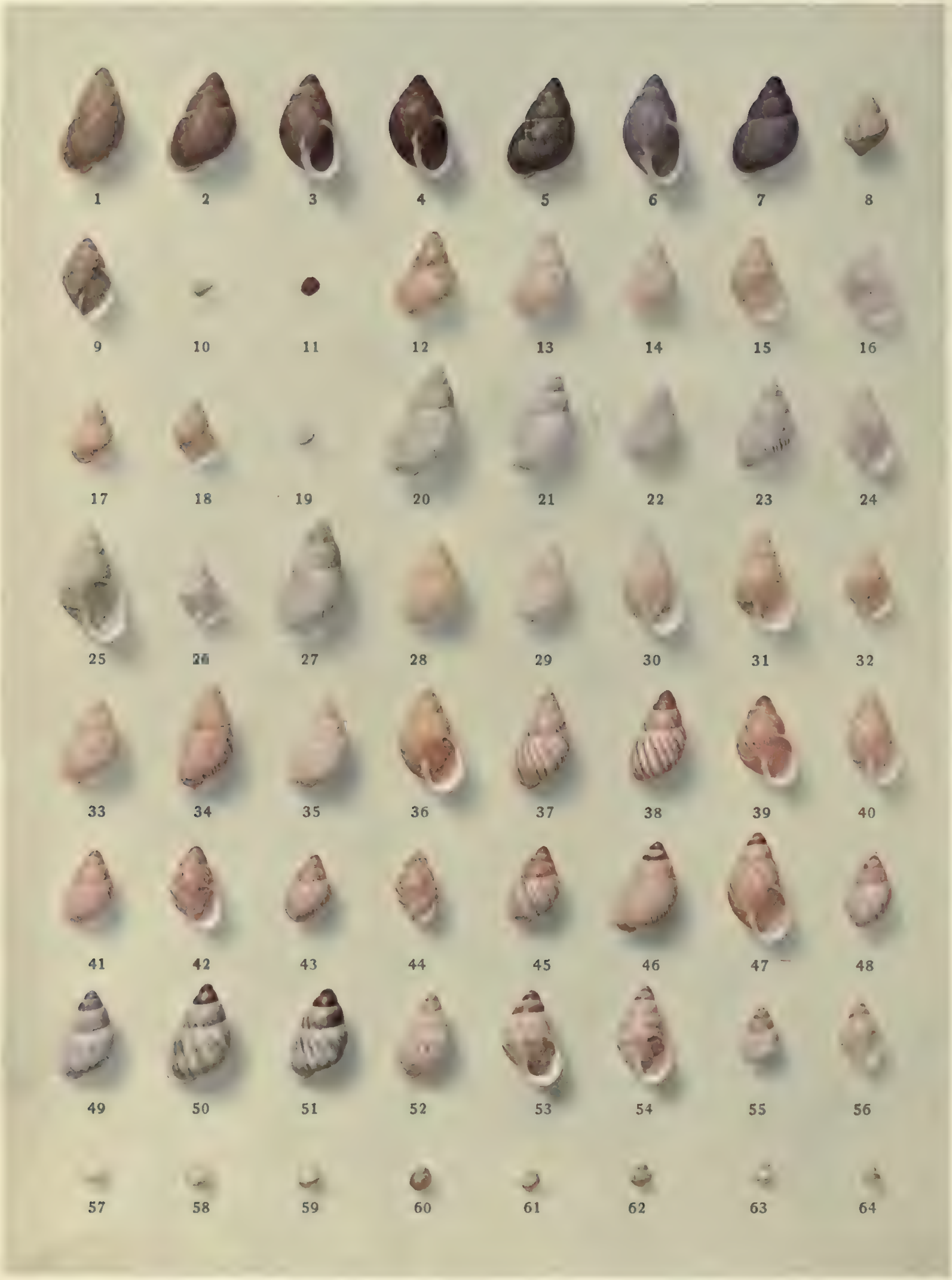

Partula salifana new species. Figs. 1-11. Partula fragilis Férussac. Figs. 12-19.
Partula radiolata Pfeiffer. Figs. 20-64.

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PLATE 11.

All shells natural size.

Figs. 1–11. *P. salifana* new species.
- Figs. 1–5. Various color types.
- Figs. 6, 7. Decorticated specimens.
- Figs. 8, 9. Adolescent shells.
- Figs. 10, 11. Embryonic shells.

Figs. 12–19. *P. fragilis* Férussac.
- Figs. 12–16. Specimens of different colors and sizes.
- Figs. 17, 18. Young adolescent shells.
- Fig. 19. Embryonic shell.

Figs. 20–26. *P. radiolata* Pfeiffer.
- Figs. 20–26. Color-class pallida.
- Figs. 27–32. Color-class flavea.
- Figs. 33–36. Color-class fulva.
- Figs. 37–44. Color-class strigata.
- Figs. 45–48. Color-order strigata-helix.
- Figs. 49–56. Color-class bicestata.
- Fig. 57. Embryo pallida from flavea adult.
- Fig. 58. Embryo flavea from pallida adult.
- Fig. 59. Embryo fulva from fulva adult.
- Figs. 60, 61. Embryo strigata from strigata adults.
- Fig. 62. Embryo strigata-helix from strigata-helix adult.
- Figs. 63, 64. Embryo bicestata from bicestata adults.

Partula gibba Férussac, Guam. Figs. 1-56.

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PLATE 12.

All shells natural size.

Figs. 1–56. *P. gibba* Férussac, from Guam.

Figs. 1–8. Color-class unicolor, Tarague.
Figs. 9–14. Color-class unicolor, Lolo.
Figs. 15–20. Color-class bicolor, Tarague.
Figs 21–23. Color-class bicolor, Aniguac.
Fig. 24. Color-class bicolor, Merizo.
Figs. 25–35. Color-class mitella, Tarague.
Figs. 36, 37. Color-class mitella, Lolo.
Figs. 38, 39. Color-class mitella, Dededo.
Figs. 40, 41. Color-class mitella, inner Presidio.
Figs. 42–44. Color-class mitella, Salifan.
Figs. 45–48. Color-order mitella-rubra, Macajna second.
Figs. 49, 50. Color-order mitella-rubra, Lonfit.
Figs. 51, 52. Color-order mitella-rubra, Tarague.
Figs. 53–56. Color-order mitella-rubra, Dededo.

Partula gibba Férussac, Guam. Figs. 1-59.

PLATE 13.

All shells natural size.

Figs. 1–59. *P. gibba* Férussac, from Guam.

Figs. 1–3. Color-order phæa-rubra, Lolo.
Fig. 4. Color-order phæa-rubra, Ukudu. Longest shell.
Figs. 5, 6. Color-order phæa-rubra, Lolo.
Fig. 7. Color-order phæa-rubra, Macajna second.
Fig. 8. Color-order phæa-rubra, Santa Rosa, decorticated.
Fig. 9. Color-order phæa-rubra, Lolo, adolescent.
Figs. 10, 11. Color-order phæa-rubra, Santa Rosa, adolescents.
Figs. 12–14. Color-order phæa-purpurea, Macajna second.
Figs. 15–19. Color-order phæa-purpurea, Asados.
Figs. 20, 21. Color-order phæa-purpurea, Macajna second, adolescents.
Figs. 22, 23. Color-order phæa-purpurea, Asados, adolescents.
Fig. 24. Color-order castanea-rubra Dededo.
Figs. 25–27. Color-order castanea-rubra, Macajna second.
Figs. 28–31. Color-order castanea-purpurea, Pago north.
Fig. 32. Color-order castanea-purpurea, Macajna second, adolescent.
Fig. 33. Color-order vespera-rosea, Lolo. Shortest and narrowest shell.
Figs. 34–42. Color-order vespera-rosea, various localities.
Figs. 43, 44. Color-order vespera-rosea, adolescents.
Figs. 45–51. Color-order vespera-cyanea, various localities.
Figs. 52–56. Color-class marginata, Dungcas.
Fig. 57. Embryonic shell, white type, from unicolor adult.
Fig. 58. Embryonic shell, tinged apex, from mitella adult.
Fig. 59. Embryonic shell, brown type, from phæa adult.

[illegible]

Partula gibba Férussac, Saipan. Figs. 1-57.

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PLATE 14.

All shells natural size.

Figs. 1–57. *P. gibba* Férussac, from Saipan.

Figs. 1–10. Color-class unicolor, shells from Sadog Tase, excepting those of figs. 6 and 8, from Fanaganam.

Figs. 11–20. Color-class bicolor, shells from Fanaganam, excepting those of figs. 12, 13, and 17, from Garapan.

Figs. 21–30. Color-class mitella, shells from Chalankiya.

Figs. 31, 34, 36, 37. Color-order mitella-rubra, Chalankiya.

Figs. 32, 33. Color-order mitella-rubra, Puntan muchut.

Fig. 35. Color-order mitella-rubra, Astaman.

Figs. 38–40. Color-order castanea-rubescens, Puntan Flores.

Figs. 41, 44, 47, 48. Color-order castanea-rubescens, Sadog Tase.

Figs. 42, 43, 45, 46. Color-order castanea-rubescens, Garapan.

Fig. 49. Color-order castanea-rubescens, Fanaganam.

Figs. 50, 52, 53, 57. Color-order castanea-purpurescens Fanaganam.

Figs. 51, 54–56. Color-order castanea-purpurescens, Garapan.